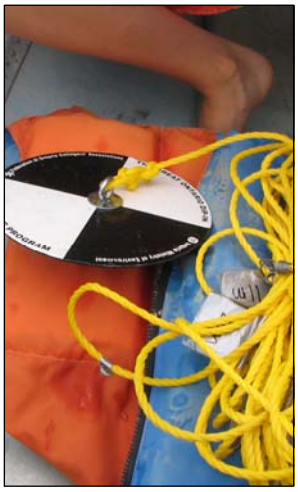

MUSKOKA LAKES ASSOCIATION

Water Quality Initiative

working in co-operation with citizensenvironmentwatch

WQI Monitoring Program Technical Report

November 30, 2007

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Executive Summary

2007 is the seventh year of the Muskoka Lakes Association's long-term commitment on behalf of the community to monitoring, protecting and enhancing the environmental resources of the Muskoka Lakes area. The Water Quality Initiative (WQI) is a formal scientifically-based monitoring program that complements monitoring programs of other agencies. Scientific protocols were originally developed by Dr. Neil Hutchinson of Gartner Lee Ltd. The MLA has been co-operating with Citizens' Environment Watch (CEW), an Ontario-based environmental charity, to deliver the monitoring program and develop local remedial action plans based on the results of the monitoring program since the fall of 2006.

Results of the WQI monitoring program are presented on an area-by-area basis in the WQI Summary Report. This Technical Report describes scientific methods, quality control measures and other technical information. It also outlines the general research conclusions. Site-by-site and year-by-year data is housed and accessible to the public online at both the MLA's (http://www.mla.on.ca) and CEW's (http://www.citizensenvironmentwatch.org) websites.

Nine community groups were affiliated with the MLA through the WQI in 2007, inlcuiding two new Affiliates (Muldrew Lakes Association and Star Lake Woods Association). Monitoring efforts grew slightly to 162 sites monitored by over 133 volunteers.

A pyramid system of volunteers was created in 2007 to help with "succession planning" and avoid volunteer burn-out. Casual volunteers were able to assist, regular Trained Volunteers were trained in the protocols by CEW staff and Team Leaders were trained to manage their team and analyze bacteria samples. This pyramid significantly increased the efficiency of the monitoring program, reducing staff time and associated costs. This also gives keen volunteers the opportunity to take on more responsibility and provides multiple commitment levels so anyone interested may volunteer.

As in previous years, the WQI monitoring program collected eight biweekly samples between Victoria Day and Labour Day. These samples were analysed for phosphorus concentration, total Coliform, *E.Coli*, water clarity and temperature. A Secchi depth protocol was added in 2007, as an alternative to turbidity for measuring water clarity. Total Coliform and *E.Coli* samples were analysed by volunteers or CEW staff using *ColiPlates*.

The WQI operates in a rich context of water quality monitoring. The most important and influential of local monitoring programs is the District of Muskoka's Lake System Health Monitoring Program, which informs all local planning regimes including mechanisms of landscape conservation and development control. This monitoring program classifies lakes based on their observed phosphorus load as compared with thresholds established by the District. A lake's classification determines its level of protection and its need for remediation.

The data collected in the WQI is primarily used to identify causes of problems identified in areas that have been classified as over-threshold for phosphorus concentration. These results are reported as part of three Remedial Action Programs (RAPs) of the MLA. The more general research purpose (discussed in this report) is to compare all deep water phosphorus concentration data to phosphorus threshold levels and subsequently help the District of Muskoka as well as neighbouring jurisdictions to ensure all areas are being appropriately protected through development regulations and enhanced through RAPs. WQI monitoring is therefore concentrated in

1. lakes and bays with problems identified by DMM;
2. lakes and bays where past WQI data indicates a problem; and
3. lakes and bays where DMM does not monitor.

Analysis (Section 5.1.1) shows that two WQI sampling areas should be considered for designation as over-threshold, two areas should be monitored by the District, three areas should have thresholds calculated and two further areas in Sequin Township may be rich in nutrients and development regulations should be considered by that jurisdiction.

Several recommendations are made for consideration in 2008. These recommendations (Section 6) include requiring a Team Leader to lead each volunteer team, improving Team

Leader training and using secchi depth as the standard measurement of water clarity while continuing to measure turbidity at nearshore zone sites in sampling areas that are subject to a RAP.

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Definitions

10-year Average Phosphorus: Arithmetic mean of all spring turnover total phosphorus concentration measurements collected over a ten year period. In order for the District of Muskoka to classify a lake or segment as over-threshold, the 10-year average of measurements collected by the District of Muskoka through the Lake System Health Monitoring Program, made up of at least three measurements, must be over the threshold calculated by the Recreational Water Quality Model.

Arithmetic mean: This type of average is calculated by adding together a group of numbers and dividing the sum by the number of numbers.

Clarity: Water clarity is influenced both by dissolved and suspended matter. Clarity often indicates a lake's overall water quality, especially the amount of algae present. Algae are natural and essential, but too much of the wrong kind can cause problems (http://www.dnr.state.wi.us/org/water/fhp/lakes/under/wclarity.htm).

***E.Coli*:** Fully known as *Escherichia Coli,* it is a subset of total coliforms, and is exclusively associated with faecal waste (Schiefer, 2001) making it a good indicator of faecal contamination. There are several different strains of *E.Coli*; most waterborn strains are themselves not harmful, but some (such as *E.Coli* O157:H7) can cause serious illness (OMH, 2001). For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#bact.

Geometric Mean: This type of average is calculated by multiplying together a group of n numbers and then taking the n^{th} root of the resulting product. Geometric mean is used to indicate the central tendency or typical value of a set of numbers (http://en.wikipedia.org/wiki/Geometric_mean). It is typically used to calculate average bacteria counts because as a living organism, bacteria counts are highly sporadic and inconsistent.

Lake System Health Monitoring Program: A field-based program designed and operated by the District of Muskoka that monitors approximately 187 sample locations across Muskoka on a rotating basis depending upon development pressures and the specific characteristics of the lake. The purpose of the program is to establish a long-term record of key water quality parameters so that trends in water quality can be identified. Spring turnover total phosphorus results of this program inform the District's Recreational Water Quality Model.
(http://www.muskoka.on.ca/planningeconomic/monitoring%20and%20stewardship.htm)

Natural Phosphorus: The "Natural" phosphorus concentration is the baseline concentration calculated by the District of Muskoka to represent the expected phosphorus concentration within the lake or bay without any development.

Phosphorus: Phosphorus is a component of DNA and RNA and an essential element for all living cells (http://en.wikipedia.org/wiki/Phosphorus). It is found in fertilizers, soaps, and in human waste. Typically phosphorus is not removed from waste streams by conventional private treatment systems (septic systems) or by some municipal treatment systems.

Lakes on the Canadian Shield are typically oligotrophic, meaning poor in nutrients. Phosphorus is usually the limiting nutrient, that is, phosphorus is in short supply so every bit of phosphorus added to the lake system is directly used to create biological matter such as algae. This makes phosphorus the most important indicator of human-based environmental impacts on our lakes. For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#eutro.

Phosphorus Threshold: The "Threshold" phosphorus concentration is 50% more than the baseline concentration, and is the threshold calculated by the District of Muskoka to classify lakes and bays as suitable for a higher level of development control as a precautionary action to protect the long-term health of the lake.

Recreational Water Quality Model: An advanced numerical model operated by the District of Muskoka designed to predict the response of all individual lakes in Muskoka to the input of phosphorus. The model is based on the Ontario Lakeshore Capacity Simulation Model, originally published in 1986 by an inter-ministerial working group. This model was substantially updated in 2005 by Dr. Neil Hutchinson of Gartner Lee Ltd. for the District of Muskoka (GLL, 2005).

The model includes a detailed phosphorus budget. Its inputs are the results of the District's Lake System Health Monitoring Program. Among the model's outputs is lake-specific Natural Phosphorus, Phosphorus Threshold and predicted phosphorus concentrations.

Sampling Area: A geographic location named in supporting documentation and encompassing a group of sites.

Secchi Depth: An expression of water clarity, measured using a secchi disk - a small disk attached to a rope. Alternating quarters of the top side of the disk are coloured white and black. The secchi depth is the depth of water whereby the sampler can no longer distinguish the white and black quarters of the disk.

Site: The discrete and unique location as identified in supporting documentation where samples are to be collected on each sample date.

Spring Turnover Phosphorus $[TP]_{so}$: A single phosphorus concentration measurement taken in a stratified lake during the spring turnover period. This measurement has been shown to adequately represent the overall phosphorus concentration in a lake. Typically the spring turnover lasts for a few days when the surface water reaches 4°C and the entire water column is able to mix. In practice, measurements taken anytime in May are considered to be

adequate by Ontario's Ministry of the Environment (http://www.ene.gov.on.ca/envision/water/lake_partner/index.htm).

Standard Deviation: The most common measure of statistical dispersion, measuring how widely spread the values in a data set are (http://en.wikipedia.org/wiki/Standard_deviation). The smaller the standard deviation, the more consistent and predictable are the numbers making up a data set. In the WQI, a large standard deviation within a year suggests that water quality is much different at different times throughout the sampling period, which could mean that specific conditions or influences are affecting water quality at a given site over the course of the season.

Total Epilimnetic Phosphorus $[TP]_{epi}$: The arithmetic mean of phosphorus concentration measurements taken above a stratified water column's thermocline over the ice-free period. Average phosphorus concentration as reported by the WQI is not a true $[TP]_{epi}$ as samples are not collected over the entire ice-free period.

Total Coliform: Coliform include a variety of bacteria. In practice, detectable coliform are usually enteric, found in the intestinal tracts of humans and other warm-blooded species. For more information, please see http://www.citizensenvironmentwatch.org/wqi/muskoka_lakes/waterquality.php#bact.

Turbidity: The cloudiness of a liquid (in this case lake water) caused by suspended particles. Turbidity is reported in Nephilometric Turbidity Units (NTU), an accurate measurement of the dispersion of light shone through the water column.

1 Introduction

The Muskoka Lakes Association (MLA) is a non-profit organization that represents the interests of lakefront residents in the Muskoka Lakes area of Central Ontario. The MLA began a formal scientifically-based ecological monitoring and lake water quality research program (WQI) in 2001. After a pilot phase led by Dr. Neil Hutchinson of Gartner Lee Ltd., the MLA continued both a monitoring program and a formal research program until 2006.

The MLA's attention was refocused in 2007, following on the recommendations of the 2006 Annual Report. Using data collected by the monitoring program the resources of the WQI have been turned on three specific sampling areas that are identified as "over-threshold" with respect to phosphorus concentration by the District of Muskoka. In other words, the research capacity has been focused on determining the sources of phosphorus loading in these areas. Resources have additionally been allocated to community-building activities designed to foster community buy-in and behaviour change.

The MLA developed a partnership with Citizens' Environment Watch (CEW) following the 2006 monitoring season. CEW is an Ontario-based environmental charity whose mandate is to support environmental education and monitoring, as well as engage the public in local decision-making. CEW provides the MLA with scientific advice and supports participants in the WQI by providing training, equipment, analysis etc. CEW also leads the facilitation of community-based remedial action plans (RCAPs).

The monitoring program was funded entirely by MLA internal revenue streams and continues to be successful because of the hard work of MLA volunteers. CEW additionally contributed funds from various revenue streams. The overall budget for the 2007 WQI including RCAPs was approximately $80 000.

The scientific details of the 2007 monitoring program are presented here. Achievements and conclusions of the three RCAP projects are reported separately.

2 Background

For simplicity and data access considerations, the detailed results of the monitoring function of the MLA program have been published online. This allows the average reader to easily access the specific results that most interest them, without having to review all the technical information produced for all data collection sites. These online results can be viewed at the MLA's website (http://www.mla.on.ca) as well as at CEW's website (http://www.citizensenvironmentwatch.org), where easy-to-read instructions and a tutorial for accessing the data are also published. MLA members can also obtain a copy of the Summary Report of 2007 Monitoring Program including instructions for accessing data via the Internet from the MLA office in Port Carling. This report should be widely distributed to MLA members.

2.1 Water Quality Monitoring Context

The MLA WQI operates in a rich context of water quality monitoring. The monitoring program that is most directly related to the WQI is the District of Muskoka's (DMM) Lake System Health Monitoring Program, in operation for over 20 years.

The DMM program collects samples in the springtime from lakes across the District (larger lakes are divided into hydrodynamicaly unique lake segments) and analyzes them for phosphorus concentration, dissolved oxygen, temperature and a number of chemical parameters including pH, conductivity, and dissolved organic carbon. There are approximately 180 monitoring sites within the district, and these are sampled on a rotational basis (Planning and Economic Development Department, 2003).

The $[TP]_{so}$ results are used to calibrate DMM's Recreational Water Quality Model. The model and $[TP]_{so}$ measurements together are used to classify lakes or lake segments by their nutrient concentrations compared with their own lake-specific background level. The background level is the concentration expected without development. Lakes are also classified by their sensitivity to nutrient loading. These classifications are used to designate specific development controls in the waterfront zone surrounding the lakes. That is, 'over-

threshold' lakes (with phosphorus concentrations greater than 50% higher than the expected background level) and lakes that are highly sensitive to phosphorus loading are subject to development controls that are much stricter than other lake classifications. For more information on DMM's monitoring program and planning regime, please contact the District Municipality of Muskoka directly (http://www.muskoka.on.ca).

Expressed more simply, the DMM program is designed to indicate whether or not there is a problem with a lake and standardized development regulations are applied to all lakes where a 'problem' is identified. The program is not intended to discover the source of problems.

The role of the MLA WQI is in fact to discover the source of problems. This is accomplished through monitoring over a longer season (Victoria Day to Labour Day) in the deep water as well as the near shore zone of a number of lakes and bays. Results of monitoring in the nearshore zone are compared to comparable deep water monitoring results to indicate land-based problem sources. A secondary focus of monitoring is the identification of problems in areas where the DMM program cannot monitor due either to lack of resources or political jurisdiction boundaries. Monitoring is therefore concentrated in

4. lakes and bays with problems identified by DMM;
5. lakes and bays where past WQI data indicates a problem; and
6. lakes and bays where DMM does not monitor.

2.2 Objectives

Objectives identified in the 2006 Annual Report were as follows:

1. Build on relationships and work more closely with the Muskoka Watershed Council (MWC) and District of Muskoka (DMM) to
    a. adopt protocols already used for various water quality indicators in Muskoka
    b. collaboratively house and make available data through new interactive web technology currently used by the MLA
2. As per direction by the Lake System Health Program (LSHP), continue to develop community-based remedial action plans for those areas identified as over-threshold with respect to total phosphorus concentration
3. Formalize public education program with regular email/website updates
4. Build a partnership with an Environmental NGO, such as Citizens' Enviroment Watch, to further develop the program and attain external funding

5. Build relationships with other residents' groups and associations in the vicinity of the Muskoka Lakes, especially program Affiliates, by hosting a social event or meeting specifically to discuss results and achievements of the initiative

Several technical recommendations were also identified in 2006:

1. Discontinue the golf course study
2. Continue research in the context of the community planning processes on over-threshold bays
3. Increase the focus on bacteria results
4. Require Affiliates to provide volunteers to analyze bacteria samples using ColiPlates and incubators
5. More thoroughly train part-time staff to ensure materials are distributed to volunteers appropriately
6. Require a trained volunteer to participate in each sample period's sampling

2.2.1 Achievement of Objectives

Tables 1 and 2 outline progress on each of the objectives identified in the 2006 Annual Report.

Table 1 - Progress on water quality initiative objectives

Objective	**Progress**
Adopt more of the protocols already used by the Watershed Council and District of Muskoka.	Meeting held in winter with MWC staff to discuss findings of WQI including additional over-threshold bays and protocols. Information submitted; no follow-up. Request for benthic monitoring support at three RCAP communities; two workshops led by DMM staff.
Collaboratively house and make available MLA, MWC and DMM data.	Lack of interest on behalf of all parties contributed to the languishing of innovative technologies and technology provider. Web presence of dataset currently being redeveloped.

Objective	Progress
Continue to develop community-based remedial action plans as directed by LSHP.	Great achievements made on behalf of all three communities identified as priorities by the MLA. These are documented in separate reports.
Formalize public education program with regular email/website updates.	Web redesigned by CEW; regular updates sent out to volunteers and RCAP community members.
Attain external funding for the program.	Limited success of donations campaign, no corporate sponsors or foundations approached. Approached Area Municipalities for support of RCAPs. Request was turned down for a number of reasons.
Build relationships with other residents' groups and associations in the vicinity of the Muskoka Lakes, especially program Affiliates.	Traditional volunteer appreciation BBQ held.

Table 2 - Progress on water quality initiative technical objectives

Objective	Progress
Discontinue 2006 "golf course study."	Discontinued
Redirect research program to RCAP context; search for sources of phosphorus loading.	Achievements of RCAPs documented in other reports.
Increase focus on bacteria results.	Bacteria results highlighted in Summary Report.
Require all Affiliates to provide volunteers ('team leaders') to analyze bacteria samples using ColiPlates.	All but one Affiliate analyzed their own samples; a total of fifteen volunteers were trained in this protocol and analyzed samples.
More thoroughly train part-time staff.	Equipment distribution problems addressed through 'team leaders' who received all equipment at the beginning of the season. Some problems remained with distribution of equipment to other teams.

Objective	Progress
Require a trained volunteer to participate in each sampling date.	A single training event was offered; volunteers also had the opportunity to come into CEW's office for personal training. Attendance at training session was approximately 65. Most volunteer teams had a trained volunteer for every date.

2.2.2 Partnerships

During the 2006 season there were no new partnerships created with any level or government or other decision-making agencies. Community groups on lakes in the vicinity of Lakes Muskoka, Joseph, and Rosseau have been very interested in the MLA's water quality initiative and the credibility that potential partnerships with the MLA and CEW could provide to their own water quality monitoring efforts. The Muldrew Lakes Association and Star Lake Woods Association both became affiliated with the MLA on the water quality initiative for the 2007 season. As a result the MLA had a total of nine community groups affiliated with the MLA's Water Quality Initiative for the 2007 season:

- Bass Lake Association
- Brandy Lake Association
- Clear Lake Association
- Gull and Silver Lakes Residents' Association (Gravenhurst)
- Moon River Property Owners' Association
- Muldrew Lakes Association
- Silver Lake Association (Township of Muskoka Lakes)
- Skeleton Lake Cottagers' Association
- Star Lake Woods Association

The MLA should begin now to develop relationships with other local associations interested in becoming Affiliates of the WQI in order to facilitate early involvement of these organizations in the 2008 water quality initiative.

3 Methods

3.1 Volunteers

During the 2007 season, 133 volunteers participated in the water quality initiative. The volunteers were divided into 31 teams that sampled each sampling area across nineteen lakes and rivers in Muskoka. Each team consisted of between one and fourteen volunteers.

A pyramid system of volunteers was created in 2007 to help with "succession planning" and avoid volunteer burn-out. Casual volunteers were able to help out on any given sample date, Trained Volunteers were trained in the protocols by CEW staff (at least one Trained Volunteer was required to participate on the team in each sample period) and Team Leaders were trained to analyze bacteria samples. The Team Leader also had responsibility for the management and coordination of their team and their equipment. Affiliates were required to supply a Team Leader; volunteer teams from within the 'big three' lakes had a Team Leader if one of the volunteers was willing to take on this responsibility.

If a volunteer team had a Team Leader, the team picked up their equipment kit from their Team Leader, collected the required samples and returned them to the Team Leader. The Team Leader then analyzed the bacteria samples and kept the phosphorus samples in the fridge until they could be sent to the laboratory for analysis. If a volunteer team did not have a Team Leader, the team picked up their equipment kit from the volunteer training session on May 19, collected the required samples and returned them to a central drop-off location where they picked up the equipment required for the next sampling date. Bacteria samples were analysed and phosphorus samples were stored all together in a central location.

Overall, fifteen volunteers were trained as Team Leaders, and 20 of the 31 teams had a Team Leader (some Team Leaders took responsibility for more than one team). The pyramid system allows volunteers to become involved at a level of experitise and commitment that they are individually comfortable with, and also provides them with a clear succession path. The Team Leaders made it possible to engage a larger number of volunteers working on the

initiative and provided more flexibility and reliable support to ensure that the required sampling was completed on each sampling day. All volunteer teams are listed in Appendix A.

3.1.1 Training

Volunteers and Team Leaders attended a training session held on Saturday, May 19 at the Port Carling Memorial Community Centre. The Volunteer session was held first. Approximately 65 volunteers attended and received an overview of the program as well as instruction on how to collect the various samples (e.g. which vessel is used for each). Volunteers also received the equipment they needed to collect the first set of samples on May 21.

The session for Team Leaders followed directly. Approximately 20 attended this session (fifteen participated as Team Leaders) where they learned how to prepare and analyse bacteria samples. The Team Leaders also received all of the equipment their volunteer team would need to collect all of the samples for the entire season and instruction on how to construct each sample period's equipment kit.

3.2 Sites

Rationale for site selection remained unchanged from previous years. Bacteria monitoring was maintained in the nearshore zone, with total phosphorus monitoring in the deep water zone. Nearshore phosphorus monitoring was also undertaken in areas that have been identified as 'over-threshold' by DMM as well as areas that are not monitored by DMM but previous WQI data suggest fit the 'over-threshold' criteria. Research focussed on three over-threshold areas identified by the MLA as priorities for Remedial Community Action Plans (RCAPs). These results are documented under a separate report for each RCAP.

The monitoring program did not substantially expand for the second consecutive year. A total of 162 sites (up from 156 sites in 2006) were monitored biweekly throughout the summer (21 May 2007 to 27 August 2007). The small expansion in number of sites monitored was due to two new Affiliates joining the WQI (Muldrew Lakes and Star Lake). A total of 162 sites were analysed for temperature, 123 sites were analysed for bacterial

contamination, phosphorus concentration was measured at 83 sites, turbidity was measured at 60 sites and secchi depth was measured at 28 sites.

In addition to including two new Affiliates, a sample area was also added at Whiteside Bay, Lake Muskoka. Monitoring sites were increased at East Portage Bay (Lake Rosseau), Mirror Lake and Muskoka Bay (Lake Muskoka) because these areas are identified as 'over-threshold' by DMM. To accommodate these changes, sampling at Arthurlie Bay (Lake Rosseau), Tobin's Island (Lake Rosseau) and Walker's Point (Lake Muskoka) areas was discontinued. Sampling at Rosseau/Shadow River was discontinued because no volunteers were found. Appendix B shows which parameters were analyzed for each site.

3.3 Sampling Dates

Use of Team Leaders allowed all samples to be collected on the same date for the first time in the history of the WQI. Table 3 shows the sample dates.

Table 3 - Sampling Dates

Sample Number	Date
1	May 21, 2007
2	June 4, 2007
3	June 18, 2007
4	July 2, 2007
5	July 16, 2007
6	July 30, 2007
7	August 13, 2007
8	August 27, 2007

3.4 Phosphorus

Total phosphorus concentration ([TP]) was measured at sites indicated in Appendix B. Digest tubes were supplied by and returned to the Trent University Laboratory at the Ministry of Environment's Dorset Environmental Science Centre. Tubes were labelled and distributed to the volunteers.

The tubes were filled directly from surface water to avoid potential problems relating to the 'container effect' in which phosphorus may adhere to the sides of sampling vessels and not be transferred to the digest tube used for analysis (Clark and Hutchinson, 1992). Volunteers used the 'plunge and sweep' method to fill digest tubes; they turned the tubes upside-down, plunged them into the lake to approximately forearm depth, turned the tube 90° and 'swept' upwards towards the surface, filling the tube. Digest tubes were kept on ice and delivered to the Team Leader or sample drop-off locations where they stayed chilled until they could be consolidated and sent to the lab in Dorset.

3.5 Total Coliform

Volunteers collected samples for total coliform analysis using 300mL juice bottles. The bottles were purchased new from the Consolidated Bottle Company or reused from previous years. The bottles and caps were sterilized in boiling water, sealed and labelled either by CEW staff or Team Leaders. The bottles were opened at the sampling location, filled with lake water (using the 'plunge and sweep' method described in Section 3.4) and resealed. The volunteers were instructed not to come in contact with either the inside of the bottle or the underside of the cap. The samples were placed on ice in the field and returned to the Team Leader or central drop-off location. Samples were either analyzed by Team Leaders, or collected from the drop-off locations and analysed by a specially trained volunteer or CEW staff.

Analysis was completed as soon as possible after receiving all of the samples. The elapsed time was routinely within 3 hours of sample collection. The samples were kept on ice, in the dark to preserve the bacteria at the naturally occurring level. Water from each sample was poured into a commercially available bacteria testing kit, as shown in Figure 1. The kit is known by the trade name *ColiPlate,* and is manufactured by Bluewater Bioscience Inc. (http://www.bluewaterbiosciences.com). Each *ColiPlate* has 96 wells containing an agar that reacts with Coliform bacteria and turns blue. Actual bacterial counts are determined by comparing the number of blue cells to a table of Most Probable Numbers (MPN). The MPN table is shown in Appendix C.

Figure 1 – ColiPlate with 11 blue wells

Any well that could be identified as any shade of blue or green was counted as a positive blue well, as per instructions from Bluewater Bioscience. Note that the *ColiPlates* have a detection limit of three counts/100mL (a count of zero blue wells corresponds to a count of "less than three" Coliform/100mL). This barrier was handled by assigning all readings of "less than three" counts of coliform/100mL sample as an absolute value of 1 count/100mL. This is a conservative estimate that reminds the reader that no untreated surface water is free from bacterial contamination.

3.6 *Escherichia Coli*

After testing for total Coliform, each *ColiPlate* was used to analyze for ***Escherichia coli*** (***E. coli***). This was done by exposing the plate to a 366nm ultraviolet light. The wells that tested positive for ***E. coli*** fluoresced under the UV light. The number of fluorescent wells was counted and the MPN of organisms/100 mL was determined by comparison with the MPN tables. After the readings were finished, the *ColiPlates* were emptied into a septic system and the plastic plates were returned to Bluewater Bioscience office to be cleaned and reused.

As with total Colifrom measurements, all readings of "less than three" counts of *E.Coli*/100mL sample as an absolute value of 1 count/100mL. This is a conservative

estimate that reminds the reader that no untreated surface water is free from bacterial contamination.

3.7 Turbidity

Turbididty was measured for samples from all sites noted in Appendix B. Water left in bacteria sampling bottles, or water collected separately for sites where bacteria was not sampled, was measured for turbidity using a HACH 2100P turbidimeter. Each sample was allowed to reach ambient temperature (to avoid fogging of the turbididty analysis vessel) and inverted once before an aliquot was taken for analysis.

3.8 Secchi Depth

A secchi depth protocol was added to the WQI monitoring program in 2007 as an alternative water clarity indicator. This protocol was added because turbidity measurements require all samples to be dropped off at a central location for analysis with an expensive turbidimeter (Section 3.7), which adds significant effort and therefore cost on behalf of volunteers and/or staff. Secchi depth was therefore used in sampling areas monitored by volunteer teams with Team Leaders (sites listed in Appendix B). Since sampling areas monitored by teams without Team Leaders delivered their samples to central locations for analysis, these samples continued to be analysed for turbidity.

Figure 2 - Secchi disk (http://www.uwosh.edu/news_bureau/releases/feb06/lake%20monitoring.htm)

Unlike turbidity, secchi depth can be evaluated in the field by trained volunteers. This protocol has been used for hundreds of years, and is still considered to be the standard measurement of water clarity. The drawbacks of using secchi depth include its accuracy (many uncontrollable factors like time of day, sunlight, wind, volunteers' eyesight etc. can affect the measurements) and secchi depth requires a water depth greater than the depth a person can see (i.e. you can't see the bottom) and is therefore not measureable at nearshore zone sites. These drawbacks originally led to the adoption of turbidity as the WQI's measure of clarity in 2002.

CEW issued a secchi disk (Figure 2) with 15m of rope (length labelled at 50cm intervals) to each volunteer team measuring secchi depth. To record the secchi depth, the volunteer lowered the secchi disk on the rope into the water on the shady side of the boat until they could no longer see it. At this point, the volunteer recorded this depth on the sample date's data sheet, lowered the disk a little further, raised the disk towards the boat until it reappeared and recorded the second depth on the same data sheet. Secchi depth was calculated as the arithmetic mean of the two recorded measurements.

3.9 Temperature

Temperature readings were recorded for all sites. Volunteers hung a pool thermometer from a rope into the surface water when first arriving at each site. After all of the other protocols were completed, the sampler then read the thermometer and recorded the reading.

4 Quality Assurance/Quality Control

No scientific program of study can claim to use or produce information that is absolutely "correct." Instead, scientific information helps people to understand how the physical environment works (in this case, how the lake ecosystem works) by collecting information through procedures that can be replicated. When analyzed and shared appropriately, this information is transformed into knowledge that helps people interact with their physical environment (Logan, 2003). There is usually great variability in information, especially when environmental parameters are being measured in the field. It is the goal of programs like the WQI, to reduce environmental variables as much as possible in order to create knowledge through scientific procedures that are both scientifically sound and replicable.

Using volunteers who are not professionally trained in field protocol and do not receive any sort of compensation for efforts further complicates a scientific research program as accountability is limited. For this reason, quality control and quality assurance protocols that aim to identify misinformation and procedural error are of utmost importance in the water quality initiative. As in all previous years since 2002, rigorous training, documentation, random duplicate measures and blank samples were used throughout the 2007 season.

4.1 Quality Assurance

Volunteers filled out and submitted data sheets providing meta-data for every sample (a sample data sheet is found in Appendix D). A trained volunteer was required to participate in each sample collection (untrained "helpers" could always assist). Training sessions were provided by CEW in May prior to the first sampling date. If a volunteer was not able to attend the training session, they had the option of being trained at another time in the CEW office in Toronto. Some experienced volunteers who were also not able to attend the training session were approved as "trained" volunteers based on their previous experience. Results of samples were recorded on paper, in MS Excel spreadsheets, and in an MS Access database. Data is additionally stored on Web servers that host the MLA water quality initiative website.

4.2 Phosphorus Quality Control

Five percent of all phosphorus samples were duplicated. These duplicates were evenly distributed over the sampling period and sample areas. The samples were collected at the same time as the regular phosphorus samples using identical TP tubes. The duplicate measurements show the range of phosphorus results that can be expected as a result of sampling and laboratory variation.

4.3 Bacteria Quality Control

Ten percent of all bacteria (total Coliform and *E.Coli*) samples were duplicated, and a further five percent of all bacteria samples were paired with a field blank sample.

4.3.1 Bacteria Duplicates

A duplicate field sample was collected by filling a sterilized 1 L mason jar using the same method as described in Section 3.5, and decanting the sample into two separate 300 mL bacteria sample jars. Five percent of the samples were tested with *ColiPlates*, the other five percent were sent to the Central Ontario Analytical Laboratory (COAL) in Orillia for professional testing. Duplicates analyzed with *ColiPlates* were evenly distributed over the sampling period and sampling areas. Duplicates analyzed by COAL were all sampled on sample dates 3 and 6 (to cut down on the travel expense to Orillia), and were evenly distributed over all sampling areas. The duplicate samples had two roles: 1) monitoring the consistency of field techniques and *ColiPlate* method and 2) comparing the *ColiPlate* method with the laboratory testing procedure.

4.3.2 Bacteria Blanks

Five percent of all bacteria samples were paired with a field blank. These field blanks were evenly distributed over the sampling period and sample areas. For this test, a 500 mL bottle of sterile (sealed) *Aquafina* water was taken into the field and then used to fill a bacteria sample bottle. If bacteria were found in the sample, it would imply that there was contamination introduced in the sampling process.

4.4 Results of QC Program

Results of the QC program are found in Appendix E.

5 Research Program Results

The long-term goal of the MLA water quality initiative is to protect and enhance environmental quality. The primary way of accomplishing this is to change the way lands adjacent to the lakes and rivers are used and developed. The MLA hopes to do this by objectively determining what land-based stressors are impairing lake systems, and what uses and styles of development are most appropriate.

Following recommendations from the 2006 Annual Report (Logan, 2006), the primary research function of the WQI is the identification of causes of specific environmental problems feeding into Remedial Action Programs (RAPs) in areas designated as over-threshold. RAPs, which include identification of sources of contamination and the development of an action plan to mitigate these sources, are required on over-threshold lakes by Section F.13 of the District of Muskoka's Official Plan (OP). No government agency is currently collecting data suitable for this problem identification. Detailed results of these activities are reported as part of three Remedial Community Action Programs currently underway on over-threshold lake segments in the MLA jurisdiction.

Recognizing that the WQI monitors many lakes and bays that the District of Muskoka does not monitor (some outside of the District), a secondary research function is to compare all deep water phosphorus concentration data to the District's phosphorus threshold levels in their OP. This way, the MLA can help the District as well as neighbouring jurisdictions to ensure that all areas are being appropriately classified and therefore protected through corresponding development regulations and improved through RAPs.

5.1 WQI Data and Phosphorus Thresholds

The District of Muskoka's LSHP, including its classification of lakes and lake segments as having low- medium- or high-sensitivity and being over- or under-threshold has been discussed at some length in Section 2.1. The District of Muskoka's OP was officially amended to include provisions of the LSHP on June 7, 2007.

The Muskoka OP (DMM, November 12, 2007) includes a list of "'Over-Threshold' Lakes for Recreational Water Quality" as Appendix K. While the OP does not make it clear how this list was composed or how it might change based on future environmental observations, the text following Section F.17 suggests that the list is determined using the criteria described in the report entitled "*Recreational Water Quality Management in Muskoka*" (GLL, 2005). This report indicates (pg. 82) that both a) the [TP] modeled by the Muskoka Water Quality Model and b) the long-term average (made up of at least three DMM $[TP]_{so}$ measurements) for a lake must exceed the threshold calculated by the model for that lake in order for it to be classified as over-threshold. Conversation with DMM staff further clarified the second criterion, namely both a) the 10-year average $[TP]_{so}$, made up of at least three yearly $[TP]_{so}$ measurements and b) the three most recent $[TP]_{so}$ measurements must all be over the calculated threshold for a lake to be classified. A lake could be de-classified if it met the inverse criteria (i.e. all measurements under-threshold) (Brouse, 2006).

Table 4 shows how the phosphorus concentration measured in each lake and lake segment monitored by the 2007 WQI compares with the lake-specific thresholds identified by the Muskoka Water Quality Model. The table indicates whether the OP classifies the lake as over-threshold and also shows the 2007 $[TP]_{so}$ measurements, ten-year averages of $[TP]_{so}$ measurements and number of $[TP]_{so}$ measurements collected in the past ten years to make up that average by both the MLA and DMM.

If the sampling area has not had a threshold calculated for it, the "Threshold Area" column indicates the nearest area that does have a threshold associated with it. In this case, the monitoring results are compared to that threshold value. If the reading in the "Threshold" column is shaded red, that sampling area is classified as over-threshold by the Muskoka OP. Other red cells indicate that that measurement is over the phosphorus threshold. Several 2007 WQI $[TP]_{so}$ samples were either missed or spoiled. These are denoted in the table with a *.

Table 4 - Comparison of 2007 [TP]so (ug/L) to Threshold Concentrations Identified in Muskoka OP

			WQI Data			DMM Data		
Sampling Area	**Threshold Area**	**Threshold**	**2007 $[TP]_{so}$**	**10 Year Average**	**No. of Samples**	**2007 $[TP]_{so}$**	**10 Year Average**	**No. of Samples**
Bala Bay		6.58	5.3	6.88	5		6.05	5
Bass Lake		9.15	10.5	10.07	3	7.5	10.18	4
Brandy Lake		28.39	*	21.27	3		22.9	1
Beaumaris		6.73	6.5	6.5	6		5.8	2
Boyd Bay	Muskoka South Basin	7.9	*	6.8	1			0
Brackenrig Bay		5.18	8.4	9.86	5	7.2		5
Clear Lake		4.79	*	12.4	1		5.9	5
Cox Bay		3.85	5.1	5.7	6	5.5	5.26	5
Dudley Bay		6.6	5.8	5.4	2		5.9	3
East Bay	Bala Bay	6.58	*	10.46	5			0
East Portage Bay		3.92	5.4	5.8	2	6	6.92	4
Gordon Bay	Joseph Main Basin	3.47	3.4	5.73	3			0
Gull Lake		8.07	*	8.05	4		8.17	5
Hamer Bay	Joseph Main Basin	3.47	5	5.38	6			0
Hoc Roc River		25.06	*	25.89	4			0
Indian River		6.22	5.2	6.51	6			0
Joseph River		4.23	7.2	7.13	3	9.3	8.9	3
Lake Joseph Main Basin		3.47	5.4	4.3	3	9.1	5.78	5
Lake Muskoka South Basin		7.9	*	4.7	1		5.43	3
Lake Rosseau Main Basin		6.22	*	7.25	2		5.65	4
Little Lake Joseph		4.64	3.3	4.69	3			0
Minett	Rosseau Main Basin	6.22	*	6.89	4			0
Mirror Lake		6.21	6.3	6.3	1		7.55	4
Muskoka Bay		10.25	8.5	10.42	6		14.42	4
Muskoka Lakes G&CC	Rosseau Main Basin	6.22	*	4.77	1			0
Muskoka River		11.08	8	8	3			0
Muskoka Sands (no Hoc Roc)	Muskoka South Basin	7.9	*	8.77	4			0
North Muldrew Lake		12	8.6	8.6	1		9.63	5
Skeleton Lake		4.45	3	3.85	2		4.2	1

			WQI Data			DMM Data		
Sampling Area	**Threshold Area**	**Threshold**	**2007 $[TP]_{so}$**	**10 Year Average**	**No. of Samples**	**2007 $[TP]_{so}$**	**10 Year Average**	**No. of Samples**
Silver Lake (Gravenhurst)		13.28	*	10.07	3	12.1	10	4
Silver Lake (Muskoka Lakes)		5.23	13.2	12.97	4	8	12.5	4
South Muldrew Lake		9.99	6.9	6.9	1		7.98	5
Stanley Bay	Joseph Main Basin	3.43	3.5	6.43	3			0
Star Lake	N/A	N/A	7.4	7.4	1			0
Still's Bay	Joseph Main Basin	3.47	4.9	5.89	5			0
Whiteside Bay		10.16	7	5.7	2		6.2	3
Willow Beach	Muskoka South Basin	7.9	*	14.05	2			0
Windermere	Rosseau Main Basin	6.22	*	5.56	3			0

Table 5 summarizes comments on sampling areas whose WQI results differ from the classification in the Muskoka OP, including recommended actions. All MLA $[TP]_{so}$ data, plotted against lake-specific threshold, are shown in Appendix F.

Table 5 - MLA data differing from LSHP classifications

Sampling Area	**Discussion**	**Recommendation**
Bala Bay	WQI 10-year average slightly above threshold.	Continue monitoring
Bass Lake	10-year averages from both WQI and DMM over-threshold.	Continue monitoring
East Bay	WQI 10-year average significantly over-threshold.	Request specific threshold to be calculated.
Gordon Bay	WQI 10-year average over-threshold, but 2007 $[TP]_{so}$ under-threshold.	Continue monitoring
Gull Lake	WQI 10-year average under-threshold.	Engage community in RAP
Hamer Bay	WQI 2007 $[TP]_{so}$ and 10 year average over-threshold. No DMM data because Hamer Bay not in Muskoka.	Consider Hamer Bay to be over-threshold and prioritize community-based action plan with support of Seguin Township.

Sampling Area	Discussion	Recommendation
Hoc Roc River	WQI 10-year average slightly over-threshold. DMM model predicts over-threshold; no DMM data available.	Request DMM monitoring to commence.
Indian River	WQI 10-year average slightly over-threshold. DMM model predicts over-threshold; no DMM data available.	Request DMM monitoring to commence.
Joseph River	WQI and DMM 2007 $[TP]_{so}$ and 10-year averages over-threshold. Meets all criteria for over-threshold classification except modeled [TP].[1]	Recommend recalibration of model and/or classification added to Muskoka OP. Engage community in RAP.
Lake Joseph Main Basin	WQI and DMM 2007 $[TP]_{so}$ and 10-year averages over-threshold. Meets all criteria for over-threshold classification except modeled [TP].[2]	Recommend recalibration of model and/or classification added to Muskoka OP. Engage community in RAP.
Lake Rosseau Main Basin	WQI 10-year average over-threshold.	Continue monitoring
Little Lake Joseph	WQI 10-year average slightly over-threshold. No DMM data because Little Lake Joseph not in Muskoka.	Continue monitoring
Minett	WQI 10-year average slightly over-threshold. No DMM data available.	Continue monitoring
Muskoka Bay	WQI 2007 $[TP]_{so}$ under-threshold.	Engage community in RAP
Muskoka Sands	WQI 10-year average over-threshold. No DMM data available.	Continue monitoring
Stanley Bay	WQI 10-year average over-threshold. No DMM data because Stanley Bay not in Muskoka.	Notify Seguin Township of findings, continue monitoring
Still's Bay	WQI 2007 $[TP]_{so}$ and 10 year average over-threshold. No DMM data.	Request specific threshold to be calculated.
Willow Beach	WQI 2007 $[TP]_{so}$ and 10 year average over-threshold. No DMM data.	Request specific threshold to be calculated.

[1] Joseph River threshold calculated as 4.23µg/L (GLL, 2005). Modeled [TP] calculated as 3.92µg/L (GLL, 2005). DMM samples taken in 2003, 2005 and 2007; all exceed threshold and average 8.90µg/L.

[2] Lake Joseph (main basin) threshold calculated as 3.47µg/L (GLL, 2005). Modeled [TP] calculated as 3.28µg/L (GLL, 2005). DMM samples taken in 1996, 1999, 2001, 2003, 2005 and 2007; all exceed threshold and average 5.48µg/L.

5.1.1 Conclusion

The wealth of $[TP]_{so}$ data that the WQI has accumulated since 2001 can be used by the MLA to help the District as well as neighbouring jurisdictions ensure that as many areas as possible are being appropriately classified, protected by development regulations and improved using RAPs. As a result of this analysis, the MLA should:

- recommend that the Muskoka Water Quality Model be recalibrated to ensure that it effectively predicts observed measurements and to ensure both the Joseph River and the Main Basin of Lake Joseph are adequately classified and protected;
- request that Muskoka begin monitoring $[TP]_{so}$ at both the Indian River and Hoc Roc River;
- request that Muskoka add East Bay, Still's Bay and Willow Beach to their water quality model, calculating thresholds for these areas; and
- notify Seguin Township that both Hamer Bay and Stanley Bay may be over-threshold, and request that they take appropriate action.

6 Recommendations

Several changes are recommended to increase the efficacy of the 2008 MLA water quality initiative.

The MLA should continue to work closely with the District of Muskoka and Area Municipalities in developing and applying the Lake System Health Program, helping the District to ensure that all areas are adequately classified and protected as per Section 5.1.1. The MLA should also work closely with Seguin Township to appropriately protect and enhance two areas in that jurisdiction that may have too-high nutrient loading.

The MLA should continue to support the community planning process started in the three over-threshold areas in 2007, and encourage other over-threshold areas to also engage in RAPs.

The MLA should continue to build a community of environmental stakeholders by planning and hosting a one-day symposium for Affiliates, other interested residents' groups and RAP community members to share their experiences and knowledge about local water quality and environmental issues. This type of event would foster a cooperative atmosphere and would likely be seen as favourable to all participants.

6.1 Technical Recommendations

The volunteer pyramid should be further developed to ensure volunteer succession and avoid fatigue. All volunteer teams should be led by a Team Leader to organize the team, the equipment and ensure that samples are collected properly.

More effort should be devoted to training volunteers in the protocols, especially QC protocols. Training should be required for all volunteers (if the volunteer has already completed training, a further session should not be necessary). Team Leaders should also be required to attend training, even if they have completed training in the past. Team Leader training should be expanded to include the construction of equipment kits on-site, and if

possible, a field component where secchi depth and QC protocols are demonstrated and practiced.

The bacteria lab duplicate protocol should be discontinued as discussed in Appendix E.

To ensure QC protocols are followed, QC protocols should be scheduled more deliberately (i.e. less randomly) and CEW staff should provide specific support regarding the QC protocols to Team Leaders before and after each scheduled QC protocol.

Secchi depth should become the standard measure of water clarity for all sampling areas monitored by volunteer teams with Team Leaders. In addition, turbidity should be measured at all monitoring sites in sampling areas subject to a RAP in order to provide more detailed information in the nearshore and deep water zones.

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November 23, 2007

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Appendix A

Volunteer Teams

Table 6 - Volunteer Teams; Team Leaders shown in **boldface**.

Lake	Sample Area	Volunteers
Muskoka	Bala Bay	Ian Baker, Arch Nordstrum, Bill Sloan
Bass	Bass Lake	**Joanne Davey**, Peter Long, Jon Sykes
Muskoka	Beaumaris	Chris Cragg, Louise Cragg, David Eddenden, Eliza Nevin, Susan Ross, Heather Smith
Muskoka	Boyd Bay	Chris Blaymires, Rayma Blaymires, John Jarvis, Thelma Jarvis, Dave Langford, Lyn Langford, **John Wood**
Rosseau	Brackenrig Bay	Danielle Guslits, Janet Palmer, Claire Phelps, James Phelps, Arianne Purves, Bud Purves, Rob Purves, Naomi Shin
Brandy	Brandy Lake	**Jim Cormack**
Clear (TML)	Clear Lake	Bill Barker, Bob Cleverdon, **Sharon Cleverdon**, Mike Muffles, Steve Ramsay
Joseph	Cox Bay	Bill Boughner, David Burrows, Fred Morrison, Frances Reid, **Gord Ross**, Keith Shantz
Muskoka	East Bay	Lloyd Walton
Rosseau	East Portage Bay	**Joan McKinnon**, Wayne McKinnon, Marcia Shortreed
Joseph	Foot's Bay	Morag MacKenzie, Janet Gould, Will Gould, **Gord Ross**
Joseph	Gordon Bay	Bob Chislett, Angela Feuchuk, Bev Rutherford, Ray Rutherford, **Andrew Watson**
Gull & Silver (GR)	Gull/Silver Lakes	Gord Lee
Joseph	Hamer Bay	Alex Herbert, Sean Sutton, **Andrew Watson**, Keith Watson
Indian River/Mirror	Indian River/Mirror Lake	**Betty Jennings**, Bill Jennings, Sandy Spence
Joseph River	Joseph River	Trip Devens, Beth Guy, Elaine Logan, Larisa Logan, Sarah Robertson, Stu Robertson
Joseph	Little Lake Joseph	Mark Johnstone, **Dirk Soutendijk**
Rosseau	Minett	John Curran, Liz Curran
Rosseau	Muskoka Lakes G&CC	John Amanatides, Sue Amanatides, Chris Reimer, Ed Reimer, Marianne Reimer, Ashley Tiemens, Ron Tiemens

Lake	Sample Area	Volunteers
Moon	Moon River	Allen Bossin, Jane Bossin, Steve Burdick, Bruce Calder, Jon Gurr, Sherri Hopkins, **Brian MacDonald**, Walt Scott, Dave Smith
Muldrew	Muldrew Lakes	**Lola Bratty**, Janice Broadfoot, Alex Brown, Bev Brown, Michael Foster, Jane Gunther, Catherine Hammond, Emily Hammond, Steven Hammond, Susan Hammond, Robert Hannah, Janice McElwain, John McElwain, Eric Steeves
Muskoka	Muskoka Bay	George Genereux, Brian Yeates, Diane Yeates
Muskoka River	Muskoka River	Debbie Hastings, **John Wood**
Muskoka	Muskoka Sands	Ted Smith, Al Ward, Carole Ward
Silver (TML)	Silver Lake (TML)	**Perry Bowker**
Skeleton	Skeleton Lake	Mario Peretti, Paul Pieper, **Alex Shepherd**
Joseph	Stanley House Bay	Anne Jonker, Gerry Jonker, **Andrew Watson**
Star	Star Lake	**Karen Gillies**, Kate Gillies, Nadia Mokriy, Peter Mokriy, Sara Slater, George Soos, Julie Soos, Donna Williamson
Muskoka	Whiteside Bay	Don Allison, Bob Crossan, Ileen Crossan, Freda Finley, John Finley
Muskoka	Willow Beach	Liz Denyar, **John Wood**
Rosseau	Windermere	**Doug Applegath**, Tim Coughlin, John Duncan, Bev Manchee, Charles Wilson, Chris Wilson
	Other	Renee & Janet Leenaars

Appendix B

Sites Monitored

Table 7 - Sites monitored.

Sites	Site	Phosphorus	Bacteria	Turbidity	Secchi Depth	Temperature
Bala Bay	BAL-0	▲		▲		▲
(Lake Muskoka)	BAL-1		▲	▲		▲
	BAL-2		▲	▲		▲
	BAL-3		▲	▲		▲
	BAL-4		▲	▲		▲
Bass Lake	BAS-0	▲			▲	▲
	BAS-1	▲			▲	▲
	BAS-2		▲			▲
	BAS-3		▲			▲
Beaumaris	BMR-0	▲		▲		▲
(Lake Muskoka)	BMR-2	▲	▲	▲		▲
	BMR-3		▲	▲		▲
	BMR-4	▲	▲	▲		▲
	BMR-5	▲	▲	▲		▲
	BMR-6	▲	▲	▲		▲
Boyd Bay	BOY-0	▲			▲	▲
(Lake Muskoka)	BOY-1		▲			▲
	BOY-2		▲			▲
	BOY-3		▲			▲
Brackenrig Bay	BRA-0	▲		▲		▲
(Lake Rosseau)	BRA-1	▲	▲	▲		▲
	BRA-2	▲	▲	▲		▲
	BRA-3	▲	▲	▲		▲
Brandy Lake	BDY-0	▲			▲	▲
	BDY-1		▲			▲
	BDY-2		▲			▲
	BDY-3		▲			▲
	BDY-5		▲			▲
	BDY-6		▲			▲
Clear Lake (TML)	CLR-0	▲			▲	▲
	CLR-1		▲			▲
	CLR-2		▲			▲
	CLR-3		▲			▲
	CLR-4		▲			▲
Cox Bay	COX-0	▲			▲	▲
(Lake Joseph)	COX-1	▲	▲			▲
	COX-2	▲	▲			▲
	COX-3	▲	▲			▲
	COX-4	▲	▲			▲
East Bay	EAS-0	▲		▲		▲
(Lake Muskoka)	EAS-1	▲	▲	▲		▲
	EAS-2	▲	▲	▲		▲
	EAS-3	▲	▲	▲		▲

Sites	Site	Phosphorus	Bacteria	Turbidity	Secchi Depth	Temperature
East Portage Bay	POR-0	▲			▲	▲
(Lake Rosseau)	POR-1	▲	▲			▲
	POR-2	▲	▲			▲
	POR-3	▲	▲			▲
	POR-4	▲	▲			▲
	POR-5	▲	▲			▲
Foot's Bay	STI-0	▲			▲	▲
(Lake Joseph)	STI-2	▲	▲			▲
	FTB-3		▲			▲
Gordon Bay	GNB-0	▲			▲	▲
(Lake Joseph)	GNB-1		▲			▲
	GNB-2		▲			▲
	GNB-3		▲			▲
	GNB-4		▲			▲
Gull Lake	GUL-0	▲		▲		▲
	GUL-1		▲	▲		▲
	GUL-2		▲	▲		▲
	GUL-3		▲	▲		▲
	GUL-4		▲	▲		▲
Hamer Bay	HMB-0	▲			▲	▲
(Lake Joseph)	HMB-1	▲	▲			▲
	HMB-2	▲	▲			▲
	HMB-3	▲	▲			▲
	HMB-4	▲	▲			▲
Indian River	IND-0	▲			▲	▲
	IND-2	▲	▲			▲
	IND-3	▲	▲			▲
Joseph River	JOR-0	▲		▲		▲
	JOR-1	▲	▲	▲		▲
	JOR-2	▲	▲	▲		▲
	JOR-3	▲	▲	▲		▲
	JOR-4	▲	▲	▲		▲
Little Lake Joseph	LLJ-0	▲			▲	▲
(Lake Joseph)	LLJ-2		▲			▲
	LLJ-4		▲			▲
	LLJ-5		▲			▲
Mid Joseph	JOS-1	▲			▲	▲
Mid Muskoka	MUS-2	▲		▲		▲
	MUS-3	▲		▲		▲
Mid Rosseau	ROS-1	▲		▲		▲
Minett	MIN-0	▲		▲		▲
(Lake Rosseau)	MIN-1	▲	▲	▲		▲
	MIN-2		▲	▲		▲
	MIN-4	▲	▲	▲		▲
	MIN-5	▲		▲		▲

Sites	Site	Phosphorus	Bacteria	Turbidity	Secchi Depth	Temperature
Mirror Lake	MIR-0	▲			▲	▲
	MIR-1	▲	▲			▲
	MIR-2	▲	▲			▲
	MIR-3	▲	▲			▲
Moon River	MOO-1		▲			▲
	MOO-3		▲			▲
	MOO-4		▲			▲
	MOO-5		▲			▲
	MOO-6		▲			▲
	MOO-7		▲		▲	▲
	MOO-8		▲			▲
	MOO-9		▲			▲
Muldrew Lake	MLD-1	▲			▲	▲
	MLD-2	▲			▲	▲
	MLD-3	▲			▲	▲
	MLD-4		▲			▲
	MLD-5		▲			▲
	MLD-6		▲			▲
	MLD-7		▲			▲
Muskoka Bay	MBA-0	▲		▲	▲	▲
(Lake Muskoka)	MBA-2	▲	▲	▲		▲
	MBA-3	▲	▲	▲		▲
	MBA-4	▲	▲	▲		▲
	MBA-5	▲	▲	▲		▲
	MBA-7	▲	▲	▲		▲
	MBA-8	▲	▲	▲		▲
	MBA-9	▲	▲	▲		▲
	MBA-10	▲	▲	▲		▲
Muskoka Lakes G&CC						
(Lake Rosseau)	MLG-0	▲		▲		▲
	MLG-1		▲	▲		▲
	MLG-2		▲	▲		▲
Muskoka River	MRV-1		▲		▲	▲
	MRV-2		▲		▲	▲
	MRV-3		▲		▲	▲
	MRV-4	▲	▲		▲	▲
Muskoka Sands	MSN-0	▲		▲		▲
(Lake Muskoka)	MSN-1		▲	▲		▲
	MSN-2		▲	▲		▲
	MSN-3		▲	▲		▲
	MSN-4	▲	▲	▲		▲
Silver Lake (GR)	SVR-0	▲		▲		▲
	SVR-1		▲	▲		▲
	SVR-2		▲	▲		▲
Silver Lake (TML)	SPC-0	▲			▲	▲
	SPC-1		▲			▲
	SPC-2		▲			▲
	SPC-3		▲			▲

Sites	Site	Phosphorus	Bacteria	Turbidity	Secchi Depth	Temperature
Skeleton Lake	SKL-5	▲			▲	▲
	SKL-1		▲			▲
	SKL-2		▲			▲
	SKL-3		▲			▲
	SKL-4		▲			▲
Stanley Bay	STN-0	▲			▲	▲
(Lake Joseph)	STN-1		▲			▲
	STN-2		▲			▲
	STN-3		▲			▲
Star Lake	STR-0	▲			▲	▲
	STR-1		▲			▲
	STR-2		▲			▲
	STR-3		▲			▲
	STR-4		▲			▲
	STR-5		▲			▲
Whiteside Bay	WTS-0	▲		▲		▲
(Lake Muskoka)	WTS-1		▲	▲		▲
	WTS-2		▲	▲		▲
Willow Beach	WLB-0	▲			▲	▲
(Lake Muskoka)	WLB-1	▲	▲			▲
	WLB-2	▲	▲			▲
	WLB-3	▲	▲			▲
Windermere	WIN-0	▲				▲
(Lake Rosseau)	WIN-1		▲			▲
	WIN-3		▲			▲
	WIN-4		▲			▲
	WIN-5		▲			▲

Appendix C

Most Probable Number Table

Bluewater Biosciences Incorporated
14 Abacus Road, Brampton, Ontario, Canada, L6T 5B7
Tel: (905) 794-3274 Fax: (905) 794-2338

COLIPLATE™-400

INTENDED USE The ColiPlate™-400 is a rapid, convenient and accurate test for quantitative measure of total coliforms and *E. coli*. The test is designed to meet regulatory guidelines for surface water, recreational water, processing water and wastewater. The ColiPlate enables quantification of coliforms and *E. coli* density ranging between ca. 3 to 2,400 cfu/ 100 mL in a single test unit without dilution. The distinctive blue/green coloration of positive tested samples enables analysis of brownish, turbid or rust filled waters.

TEST PRINCIPLE AND FEATURES The ColiPlate test utilizes the proven X-Gal and MUG techniques to detect viable coliforms and/or *E. coli* bacteria. The ColiPlate contains selective media to provide nutrients to stimulate the growth of coliforms and *E. coli*. The media also contains inducers and chromogenic/fluorogenic substrates. These substrates react with specific enzyme indicative of coliforms (beta-D-galactosidase) and *E. coli* (beta-D-glucoronidase) to provide color change to blue/green and fluorescence by coliforms and *E. coli* respectively. Test results are recorded after just 24 hours of incubation with the appearance of blue/green color for coliforms. *E. coli* can be detected by the appearance of fluorescence under a long wavelength UV light. Quantification is based on Most Probable Number (MPN) of colony forming-units (cfu) per 100 mL sample.

MPN TABLE

No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample	No. Wells Giving Positive Reaction	MPN per 100 mL Sample
0	<3						
1	3	25	76	49	182	73	388
2	5	26	79	50	188	74	403
3	8	27	83	51	194	75	418
4	11	28	87	52	200	76	434
5	13	29	90	53	206	77	451
6	16	30	94	54	213	78	469
7	19	31	98	55	219	79	489
8	22	32	102	56	226	80	510
9	25	33	106	57	233	81	534
10	28	34	110	58	240	82	559
11	30	35	114	59	247	83	587
12	33	36	119	60	255	84	619
13	36	37	123	61	263	85	654
14	39	38	127	62	271	86	694
15	43	39	132	63	280	87	740
16	46	40	136	64	289	88	794
17	49	41	141	65	298	89	858
18	52	42	146	66	307	90	938
19	55	43	151	67	317	91	1,038
20	59	44	156	68	328	92	1,174
21	62	45	161	69	339	93	1,370
22	65	46	166	70	350	94	1,696
23	69	47	171	71	362	95	2,424
24	72	48	177	72	375	96	>2,424

Figure 3 - MPN Table

Appendix D

Data Sheet

BDY – Brandy Lake

General Information

Date		**Sample Time**	
Trained Sampler		**Other Volunteers**	
Rainfall (heavy, moderate, light, none)		**Air Temp.**	

Secchi Depth (if necessary)

"Down" Depth		**"Up" Depth**	

For Lab use

Preparation Time		**Analysis Time**	

Site Specific Information

For lab use

Site Code	Water Temp.	Waves	Water Depth	Distance from Shore	Blue	TC Count	Flor.	EC Count	Turb.
BDY-0		☐ Calm ☐ Rough							
BDY-1		☐ Calm ☐ Rough							
BDY-2		☐ Calm ☐ Rough							
BDY-3		☐ Calm ☐ Rough							
BDY-5		☐ Calm ☐ Rough							
BDY-6		☐ Calm ☐ Rough							

Figure 4 - Sample Data Sheet

Appendix E

QA/QC Results

E.1 Bacteria Blanks

Field blank measurements are intended to determine if field samples are being contaminated. Possible sources of contamination of blanks include:

- improper sterilization of collection bottles;
- breaking of seals on the bottles after sterilization;
- improper storage or contamination of ColiPlates; and
- contamination of the samples by volunteers.

It is also possible that volunteers mistakenly submitted and/or analysed "lake water" as blank samples.

Table 8 - Field Blank Results

Sample Number	Site	TC Blank	EC Blank	Turb Blank	Sampler
1	BDY-2	1	1		J. Cormack
1	MLD-6	1	1		B. Brown
1	MOO-3	1	1		D. Smith
1	SPC-2	1	1		P. Bowker
1	STR-1	1	1		S. Slater
2	BMR-5	1	1	0.38	L. Cragg
2	CLR-3	1	1		S. Cleverdon
2	MBA-5	1	1	0.23	B. Yeates
2	MLD-5	1	1		J. McElwain
2	SKL-2	16	13		A. Shepherd
3	GNB-3	1	1		B. Rutherford
4	CLR-4	1	1		S. Cleverdon
4	MIR-2	1	1		S. Spence
4	SKL-3	1	1		A. Shepherd
5	BAL-1	1	1	0.29	B. Sloan
5	BDY-6	1	1		J Cormack
5	COX-1	1	1		F. Reid
5	GNB-1	1	1		B. Rutherford
5	GUL-3	1	1		G. Lee
5	LLJ-2	11	1		D. Soutenouk
5	MLG-1	11	1	0.29	E. Reimer
5	POR-1	1	1		J. McKinnon
5	SKL-4	3	3		A. Shepherd
5	WIN-5	16	1		J. Duncan
6	STN-3	39	1		A. Jonker
7	POR-3	1	1		M. Shortread
7	STI-2	1	1		J. Gould
8	STR-2	3	1		K. Gillies

Table 8 shows the results of blanks (readings of total coliform (counts/100mL), *E.Coli* (counts/100mL) and turbidity (NTU)), sorted by sampling date. Note that as previously mentioned, all samples where the ColiPlate result was <3 bacteria counts/100mL are conservatively reported as 1 bacteria count/100mL. A reading of one count in Table 8 therefore does not necessarily represent contamination in the blank sample. Seven of 28 blank samples (25%) therefore showed contamination (highlighted in yellow). This level of contamination is higher than observed in 2006 or previous years.

In previous years, it was often possible to conclude that some contaminated blank samples were actually "lake water" rather than *Aquafina* based on the sample's turbidity. This is not generally possible in 2007, since most of the blank samples were not tested for turbidity (Team Leaders not able to measure turbidity).

Only 28 out of 48 scheduled blank samples were submitted by volunteers (58%). This return rate is even lower than in 2006 (63%) and in previous years. Return rate was 66% for sampling areas with Team Leaders and 38% for sampling areas without Team Leaders. The higher return rate for areas with Team Leaders may be attributed to that person receiving all necessary equipment and training, and taking responsibility for all samples being collected. More emphasis should be placed on QC protocols in training sessions in the future in order to raise the rate of return.

Contamination in seven out of 28 samples indicates contamination from any of the aforementioned sources, but it is impossible to know which one. Special effort should be made to train Team Leaders in sterilization techniques and proper field blank sampling protocols in order to a) improve the rate of return of field blank samples and b) lower the rate of contamination.

E.2 Bacteria *ColiPlate* Duplicates

ColiPlate duplicate measurements are intended to determine if *ColiPlates* report bacteria counts consistently.

Table 9 – Total Coliform Duplicates Analyzed with ColiPlates

Sample Number	Site	Total Coliforms	TC ColiPlate Duplicate	Sampler
1	BAL-3	3	1	A. Nordstum
1	MIR-1	19	46	S. Spence
1	POR-3	25	11	M. Shortread
1	SKL-1	1	1	A. Shepherd
2	BAL-4	182	151	L. Wait
2	BDY-3	194	188	J. Cormack
2	COX-4	19	16	K. Shantz
2	HMB-4	25	43	A. Watson
2	JOR-3	5	1	S. Robertson
2	STR-2	33	43	K. Gillies
3	GNB-1	33	46	B. Rutherford
3	HMB-1	151	87	A. Watson
3	STN-1	43	19	A. Jonker
4	BDY-5	19	19	J. Cormack
4	GNB-4	11	11	B. Rutherford
4	HMB-1	59	30	A. Watson
5	BRA-1	62	132	A. Purves
5	MIN-2	83	65	J. Curran
5	POR-5	102	94	J. McKinnon
5	SPC-3	22	16	P. Bowker
5	STN-1	22	8	A. Jonker
5	WTS-1	16	39	B. Crossan
6	FTB-3	49	72	J. Gould
6	GNB-3	39	39	B. Rutherford
6	HMB-2	2500	1370	A. Watson
6	STR-1	79	83	K. Gillies
6	WIN-3	146	39	J. Duncan
7	BDY-2	72	62	J. Cormack
7	HMB-1	1174	2500	A. Watson
7	IND-2	200	177	B. Jennings
7	JOR-1	1	13	B. Guy
7	WIN-5	156	213	J. Duncan
8	LLJ-4	166	87	M. Johnstone
8	MLD-7	188	171	M. Foster

Table 9 shows the results of total Coliform duplicates analyzed using *ColiPlates*, sorted by sampling date. All units are counts/100mL. A two-tailed Student's paired T-test is appropriate for determining whether or not the *ColiPlates* consistently report total Coliform counts.

Performing the T-test on the TC and TC duplicate datasets from Table 9 returns a P-value of **0.997**. In other words, the probability that the TC and TC duplicate datasets are the "same" (i.e. *Coliplates* report counts consistently) is 99.7%. This probability is above the accepted statistical confidence threshold (α) of 95%.

Table 10 - E.Coli Duplicates Analyzed with ColiPlates

Sample Number	Site	EColi	EC ColiPlate Duplicate	Sampler
1	MIR-1	5	1	S. Spence
1	POR-3	1	3	M. Shortread
1	SKL-1	1	1	A. Shepherd
2	BAL-4	55	62	L. Wait
2	BDY-3	33	30	J. Cormack
2	COX-4	1	1	K. Shantz
2	HMB-4	5	5	A. Watson
2	JOR-3	3	1	S. Robertson
2	STR-2	1	1	K. Gillies
3	GNB-1	3	5	B. Rutherford
3	HMB-1	11	8	A. Watson
3	STN-1	1	1	A. Jonker
4	BDY-5	3	3	J. Cormack
4	GNB-4	1	1	B. Rutherford
4	HMB-1	5	1	A. Watson
5	BAS-2	8	1	J. Davey
5	BRA-1	3	19	A. Purves
5	MIN-2	3	5	J. Curran
5	POR-5	8	5	J. McKinnon
5	SPC-3	5	5	P. Bowker
5	STN-1	1	1	A. Jonker
5	WTS-1	3	3	B. Crossan
6	FTB-3	1	1	J. Gould
6	GNB-3	3	11	B. Rutherford
6	HMB-2	13	11	A. Watson
6	STR-1	3	8	K. Gillies

Sample Number	Site	EColi	EC ColiPlate Duplicate	Sampler
6	WIN-3	1	1	J. Duncan
7	BDY-2	1	1	J. Cormack
7	HMB-1	3	3	A. Watson
7	IND-2	30	22	B. Jennings
7	JOR-1	1	1	B. Guy
7	WIN-5	1	1	J. Duncan
8	LLJ-4	8	3	M. Johnstone
8	MLD-7	11	11	M. Foster

Table 10 shows the results of *E.Coli* duplicates analyzed using *ColiPlates*, sorted by sampling date. All units are counts/100mL. A two-tailed Student's paired T-test is appropriate for determining whether or not the *ColiPlates* consistently report *E.Coli* counts.

Performing the T-test on the EC and EC duplicate datasets from Table 10 returns a P-value of **0.968**. In other words, the probability that the EC and EC duplicate datasets are the "same" (i.e. *Coliplates* report counts consistently) is 96.8%. This probability is above the accepted statistical confidence threshold (α) of 95%.

Only 34 out of 49 scheduled *ColiPlate* duplicate samples were submitted by volunteers (69%). Return rate was 79% for sampling areas with Team Leaders and 47% for sampling areas without Team Leaders. The higher return rate for areas with Team Leaders may be attributed to that person receiving all necessary equipment and more specialized training, and taking responsibility for all samples being collected. More emphasis should be placed on QC protocols in training sessions in the future in order to raise the rate of return.

E.3 Bacteria Lab Duplicates

Laboratory duplicate measurements are intended to determine if *ColiPlates* report bacteria counts accurately compared with accepted laboratory proceedures.

Table 11 - Total Coliform Duplicates Analyzed by Laboratory

Sample Number	Site	Total Coliforms	TC Lab Duplicate	Sampler
3	BDY-1	98	13	J. Cormack
3	BOY-1	5	10	C. Blaymires
3	EAS-1	19	6	L. Walton
3	GUL-1	36	35	G. Lee
3	LLJ-2	52	11	M. Johnstone
3	MOO-4	90	33	D. Smith
3	MRV-1	106	38	J. Wood
3	POR-1	1	9	M. Shortread
3	SPC-1	52	15	P. Bowker
3	WIN-1	177	32	M. Logan
3	WLB-1	13	2	L. Denyar
6	BAL-2	43	7	B. Sloan
6	BMR-3	161	33	L. Cragg
6	BOY-2	240	22	L. Langford
6	BRA-2	1370	37	J. Phelps
6	COX-2	30	6	B. Boughner
6	GUL-2	83	25	G. Lee
6	JOR-2	1370	7	B. Guy
6	LLJ-4	25	15	D. Soutendijk
6	MBA-3	33	32	B. Yeates
6	MIN-4	794	12	J. Curran
6	MLG-2	350	37	E. Reimer
6	MRV-2	141	36	J. Wood
6	MSN-2		72	A. Ward
6	WLB-2	146	23	L. Denyar
6	WTS-2	123	66	D. Allison

Table 11 shows the results of total Coliform duplicates analyzed by COAL, sorted by sampling date. All units are counts/100mL. A two-tailed Student's paired T-test is appropriate for determining whether or not the *ColiPlates* return the "same" results as the laboratory procedure.

Performing the T-test on the TC and TC duplicate datasets from Table 11 returns a P-value of **0.015**. In other words, the probability that the TC and TC duplicate datasets are the "same" (i.e. *Coliplates* and COAL report counts consistently) is 1.5%. This probability is well below the accepted statistical confidence threshold (α) of 95% meaning that *ColiPlates* and COAL are not consistent.

A closer look at the data indicates that the arithmetic mean of the TC dataset (*ColiPlates*) is 222, while the arithmetic mean of the TC duplicate dataset (COAL) is 24. Moreover, five of the duplicated *ColiPlate* measurements are larger than 200 counts/100mL and *ColiPlates* are designed to estimate high counts conservatively. This large discrepancy between TC and TC duplicate datasets may therefore be directly related to the particular readings that were randomly selected for duplication. Nevertheless, conservative estimates of total Coliform are acceptable.

Table 12 - *E.Coli* Duplicates Analyzed by Laboratory

Sample Number	Site	EColi	EC Lab Duplicate	Sampler
3	BDY-1	33	6	J. Cormack
3	BOY-1	1	2	C. Blaymires
3	EAS-1	3	2	L. Walton
3	GUL-1	1	8	G. Lee
3	LLJ-2	1	1	M. Johnstone
3	MOO-4	8	10	D. Smith
3	MRV-1	3	6	J. Wood
3	POR-1	1	0	M. Shortread
3	SPC-1	8	5	P. Bowker
3	WIN-1	1	0	M. Logan
3	WLB-1	3	1	L. Denyar
6	BAL-2	1	0	B. Sloan
6	BMR-3	28	15	L. Cragg
6	BOY-2	1	1	L. Langford
6	BRA-2	3	1	J. Phelps
6	COX-2	1	0	B. Boughner
6	GUL-2	3	3	G. Lee
6	JOR-2	1	0	B. Guy
6	LLJ-4	3	6	D. Soutendijk
6	MBA-3	1	1	B. Yeates
6	MIN-4	1	3	J. Curran
6	MLG-2	3	4	E. Reimer
6	MRV-2	16	15	J. Wood
6	MSN-2		21	A. Ward
6	WLB-2	5	6	L. Denyar
6	WTS-2	11	13	D. Allison

Table 12 shows the results of *E.Coli* duplicates analyzed by COAL, sorted by sampling date. All units are counts/100mL. A two-tailed Student's paired T-test is appropriate for

determining whether or not the *ColiPlates* return the "same" results as the laboratory procedure.

Performing the T-test on the EC and EC duplicate datasets from Table 12 returns a P-value of **0.322**. In other words, the probability that the EC and EC duplicate datasets are the "same" (i.e. *Coliplates* report counts consistently) is 32.2%. This probability is well below the accepted statistical confidence threshold (α) of 95% meaning that *ColiPlates* and COAL are not consistent.

A closer look at the data indicates that the arithmetic mean of the EC dataset (*ColiPlates*) is 5.6, while the arithmetic mean of the EC duplicate dataset (COAL) is 4.4. As with the TC and TC duplicate comparison above, the *ColiPlates* conservatively estimated counts.

A drawback to this analysis is that the two datasets should not be the "same," as they are derived using two different scientific methods. Therefore, a much more robust comparison is required to draw accurate conclusions about the efficacy of *ColiPlates* in general. Several in-depth studies have shown that *ColiPlates* and the methodology that they use do, in fact, accurately report bacteria counts (e.g. Lifshitz, Ran and Renu Joshi, 1998).

Only 26 out of 51 scheduled Laboratory duplicate samples were submitted by volunteers (51%). Return rate was 48% for sampling areas with Team Leaders and 55% for sampling areas without Team Leaders. The lower return rate for areas with Team Leaders may be attributed to the logistical problems associated with physically collecting all of the duplicate samples from the Team Leaders so they could be transported to COAL (Team Leaders were not used to doing this procedure). Due to the availability of in-depth research comparing the efficacy of the ColiPlate technology, our inability to accurately compare the samples and duplicates and the challenges with collecting samples from Team Leaders, the laboratory duplicate protocol should be discontinued in 2008.

E.4 Phosphorus Duplicates

Phosphorus duplicate measurements are intended to determine the range and variation of phosphorus measurements returned by the lab.

Table 13 - Phosphorus Duplicates

Sample Number	Site	Phosphorus Concentration	P Duplicate	Absolute Difference	Sampler
1	BRA-0	8.4	10	1.6	J. Phelps
1	COX-0	5.1	7.1	2	G. Ross
1	JOR-0	7.2	7	0.2	S. Robertson
1	STI-0	4.9	5.5	0.6	J. Gould
2	IND-0	11.1	9.6	1.5	B. Jennings
2	LLJ-0	3.3	4.9	1.6	D. Soutendijk
2	MIN-0	4.1	4.8	0.7	J. Curran
2	POR-0	7	4.2	2.8	J. McKinnon
2	POR-4	3.4	11.9	8.5	J. McKinnon
3	MBA-2	9.5	22.1	12.6	B. Yeates
3	SKL-5	3	4.6	1.6	A. Shepherd
3	STR-0	9.8	9.4	0.4	G. Soos
4	BAL-0	6.4	5.8	0.6	B. Sloan
4	BMR-0	5.5	6.6	1.1	D. Eddenden
4	BOY-0	7.2	8.4	1.2	C. Blaymires
4	GUL-0	7.8	10.4	2.6	G. Lee
4	MBA-3	9.9	10.6	0.7	B. Yeates
4	MIR-3	14.2	15.4	1.2	S. Spence
4	WIN-0	5.3	5.9	0.6	J. Duncan
5	EAS-2	11.3	9.4	1.9	L. Walton
5	MBA-0	9.1	7.3	1.8	B. Yeates
5	MRV-4	10	9.5	0.5	J. Wood
5	MSN-0	7.5	8.2	0.7	A. Ward
5	POR-3	15.2	7.9	7.3	J. McKinnon
5	WLB-0	6	9.3	3.3	L. Denyar
6	BDY-0	23.8	20.8	3	J Cormack
6	CLR-0	14.9	19.8	4.9	S. Cleverdon
6	SPC-0	8.7	8.1	0.6	P. Bowker
7	GNB-0	3.4	3.1	0.3	B. Rutherford
8	BRA-3	8	8.8	0.8	B. Purves
8	COX-3	5.9	4.4	1.5	K. Shantz
8	MBA-0	6.8	10.5	3.7	B. Yeates
8	STN-0	4.7	3.3	1.4	A. Jonker

Table 13 shows the results of phosphorus duplicates sorted by sampling date. The absolute value of the difference betweens P and P duplicate measurements are also shown. All units are µg/L.

The mean absolute difference between the measurements is 2.24 µg/L, the median absolute difference is 1.5 µg/L and the standard deviation is 2.65 µg/L. The maximum difference is 12.6 µg/L. This suggests that most often, the error observed in phosphorus concentration is +/- 2.65 µg/L.

33 out of 32 scheduled Phosphorus duplicate samples were submitted by volunteers (103%). Return rate was 95% for sampling areas with Team Leaders and 118% for sampling areas without Team Leaders. The higher return rate for phosphorus duplicates than any other QC protocol may be attributed to the fact that the protocol is very easy to understand and cannot be confused with other protocols.

Appendix F

WQI [TP] Results Plotted Against Threshold Values

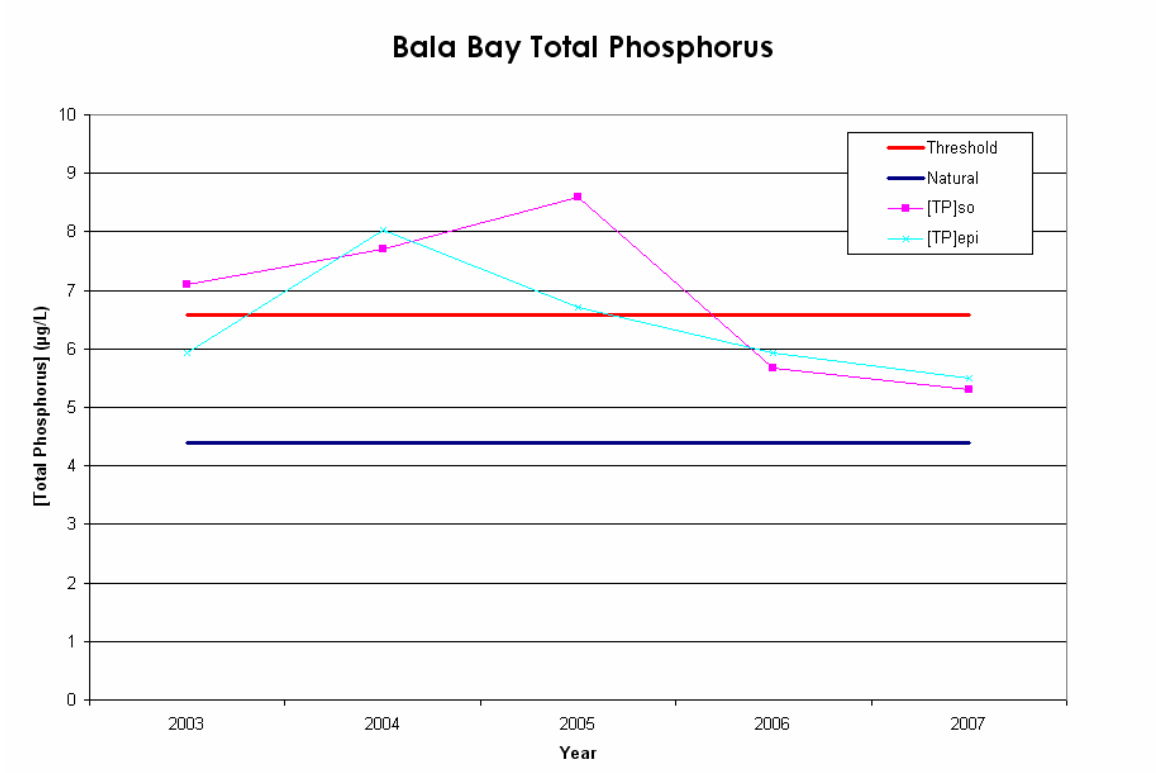

Figure 5 - Bala Bay Total Phosphorus

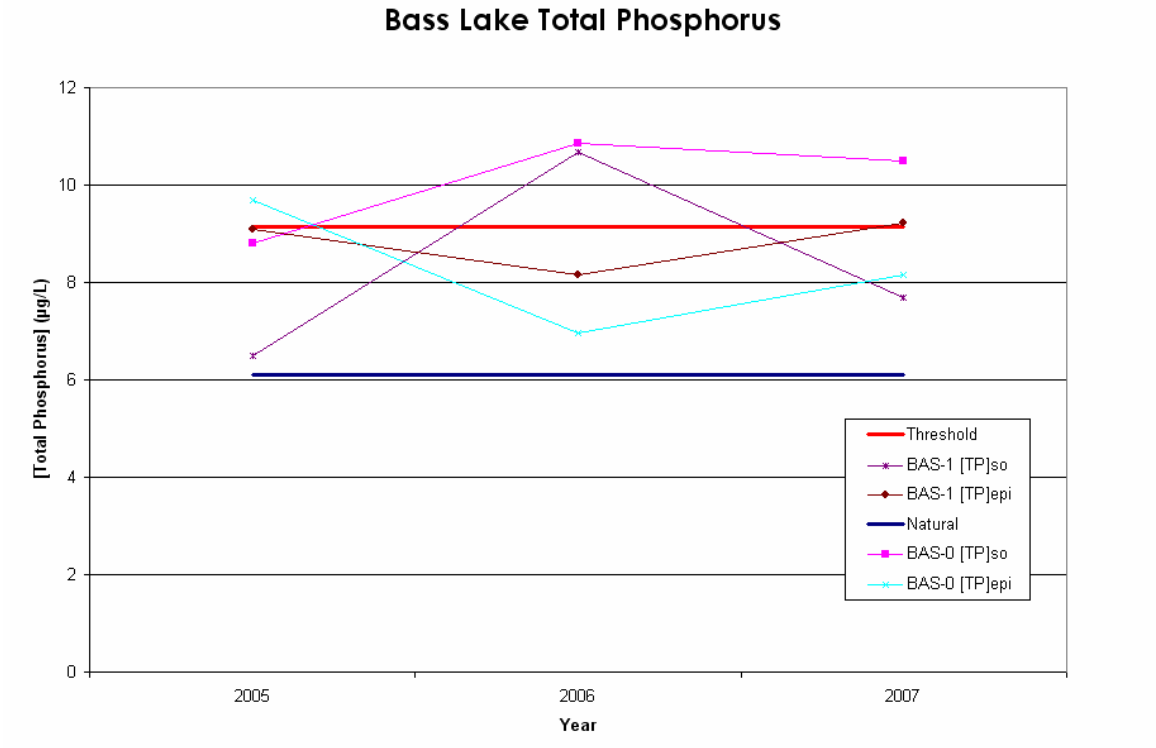

Figure 6 - Bass Lake Total Phosphorus

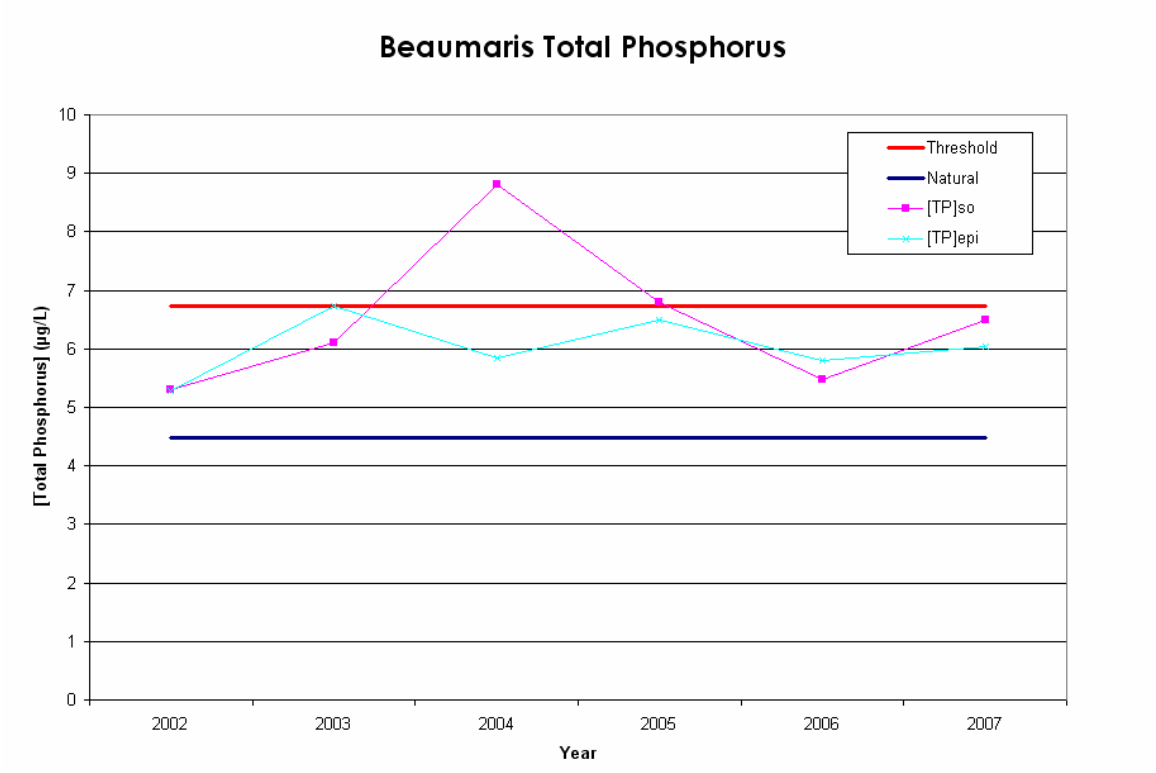

Figure 7 - Beaumaris Total Phosphorus

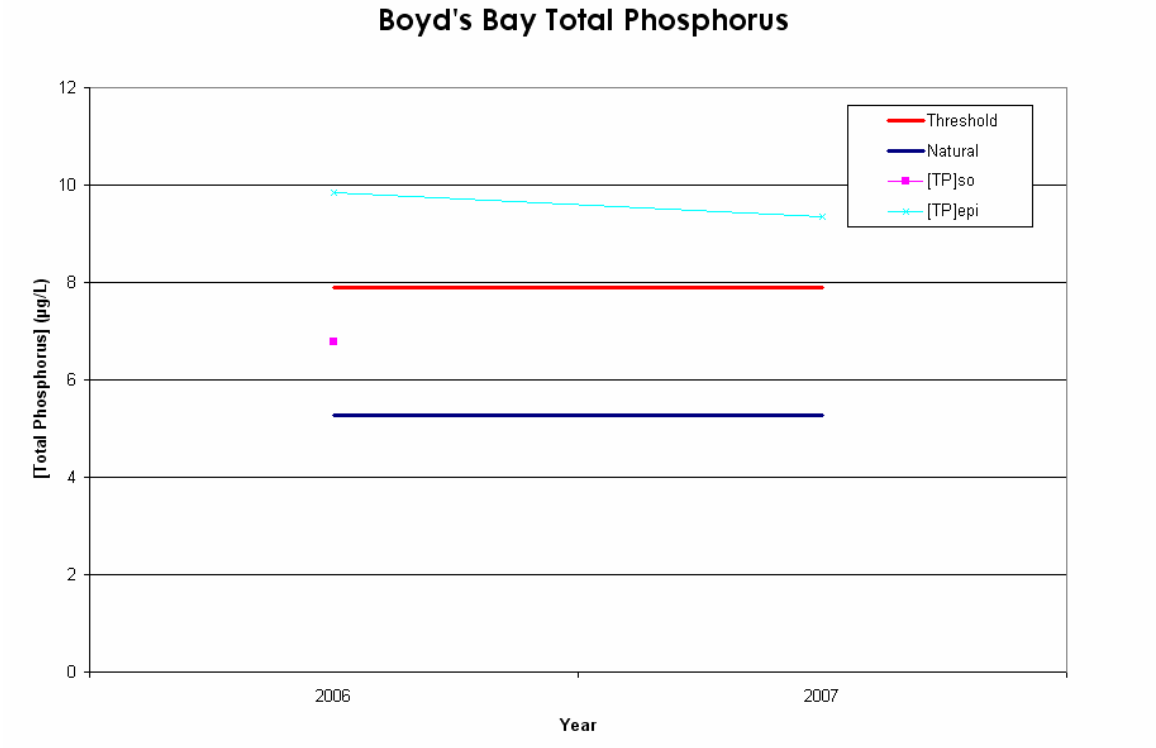

Figure 8 – Boyd Bay Lake Total Phosphorus

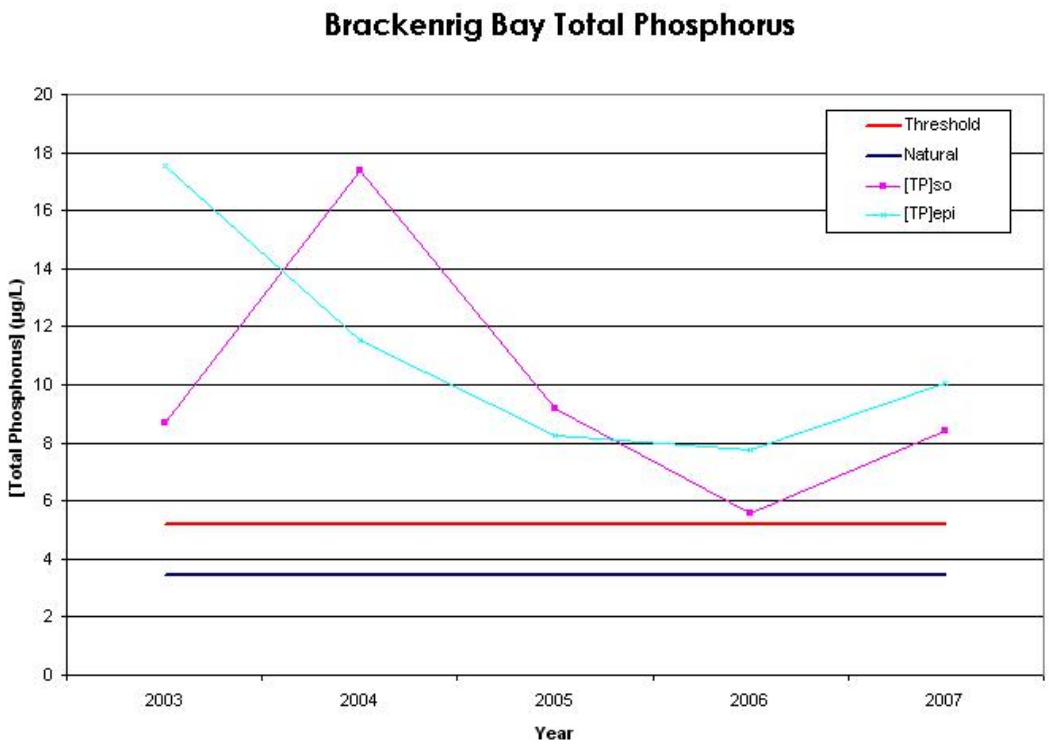

Figure 9 - Brackenrig Bay Total Phosphorus

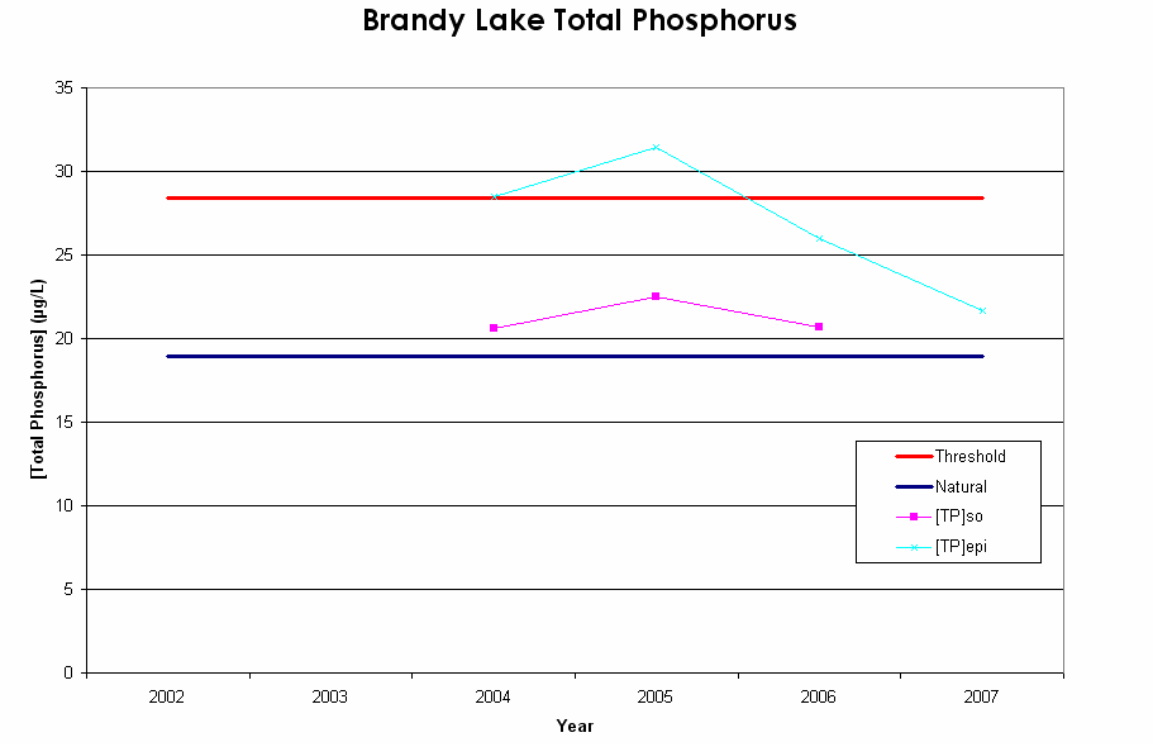

Figure 10 - Brandy Lake Total Phosphorus

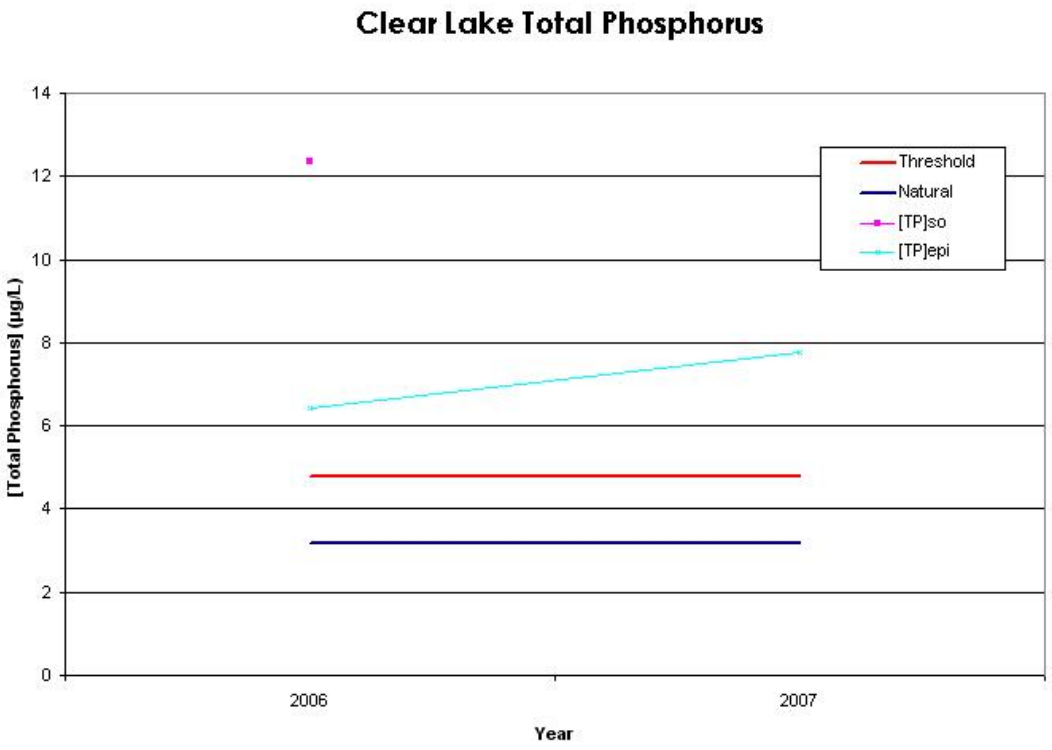

Figure 11 - Clear Lake Total Phosphorus

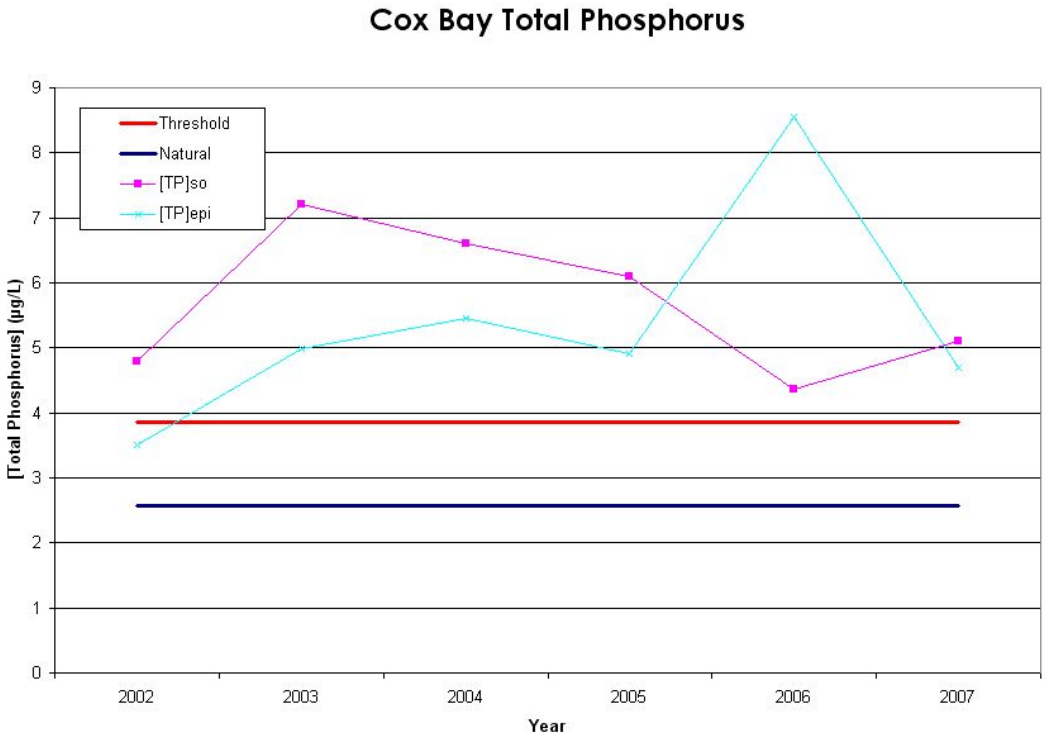

Figure 12 - Cox Bay Total Phosphorus

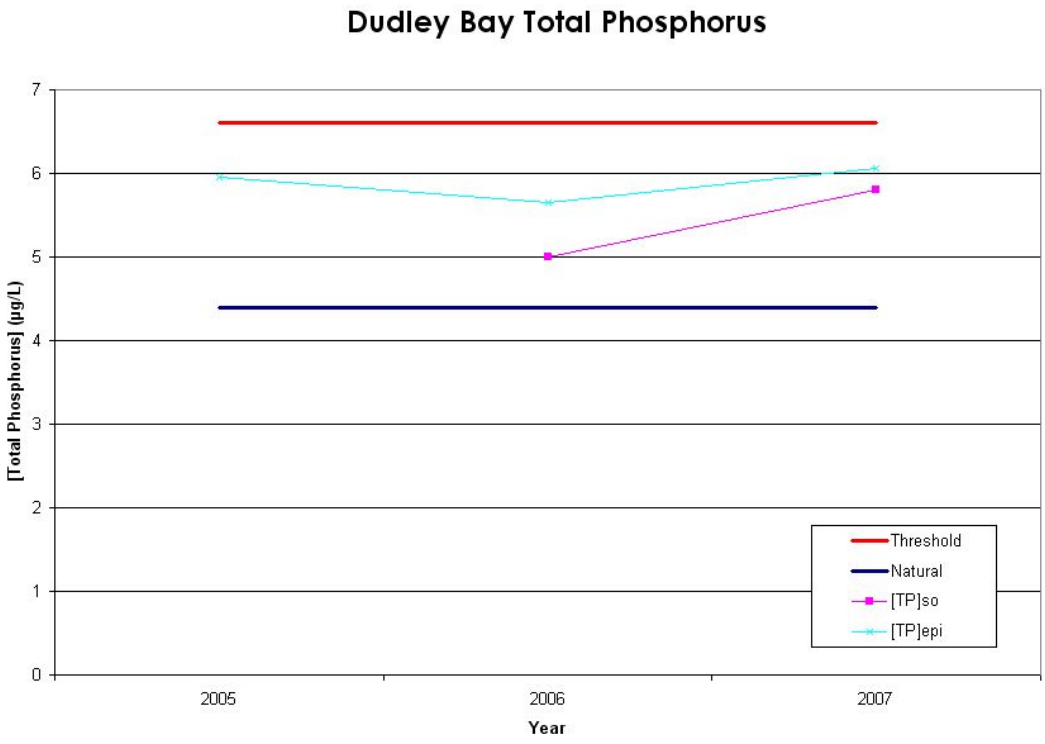

Figure 13 - Dudley Bay Total Phosphorus

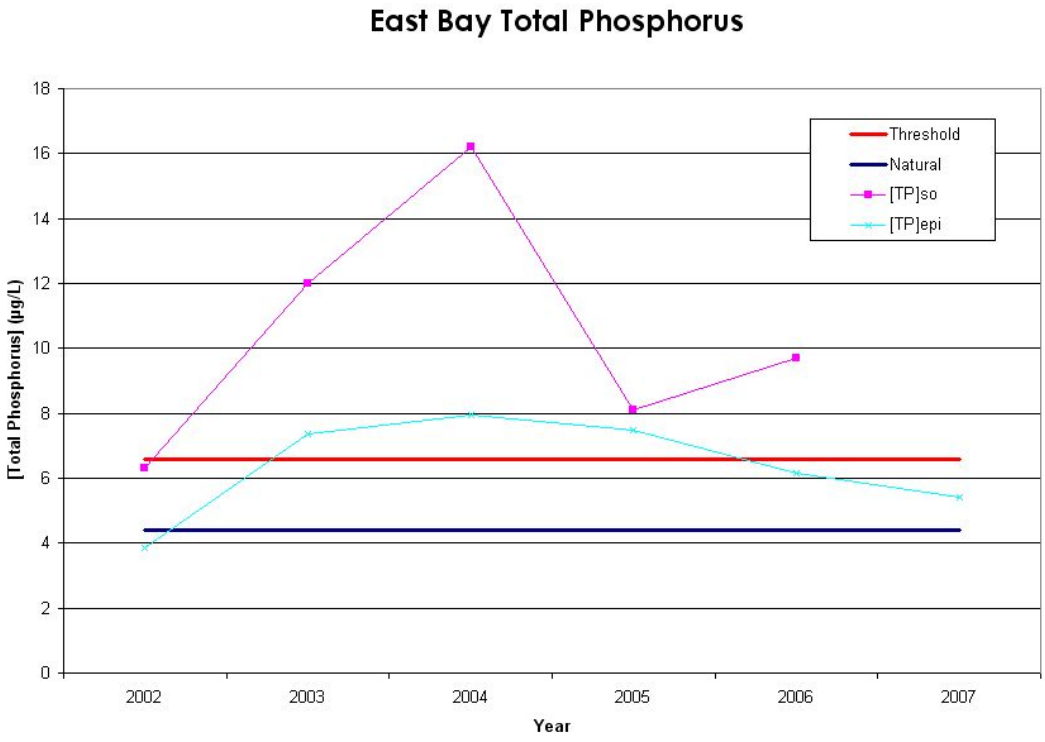

Figure 14 - East Bay Total Phosphorus

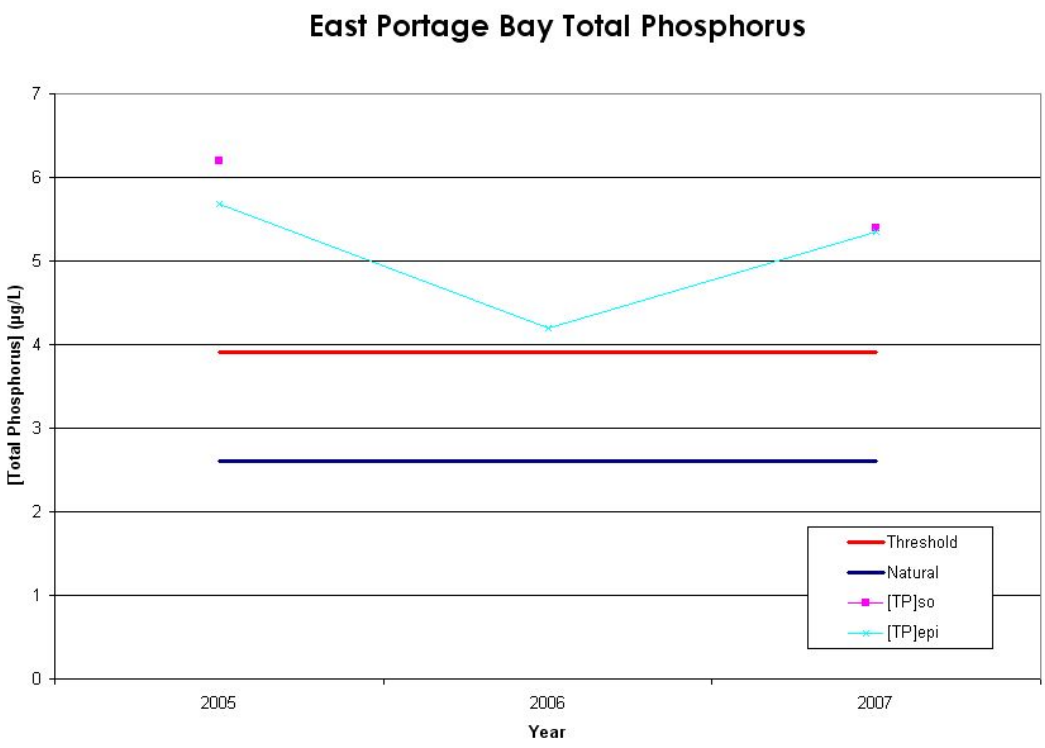

Figure 15 - East Portage Bay Total Phosphorus

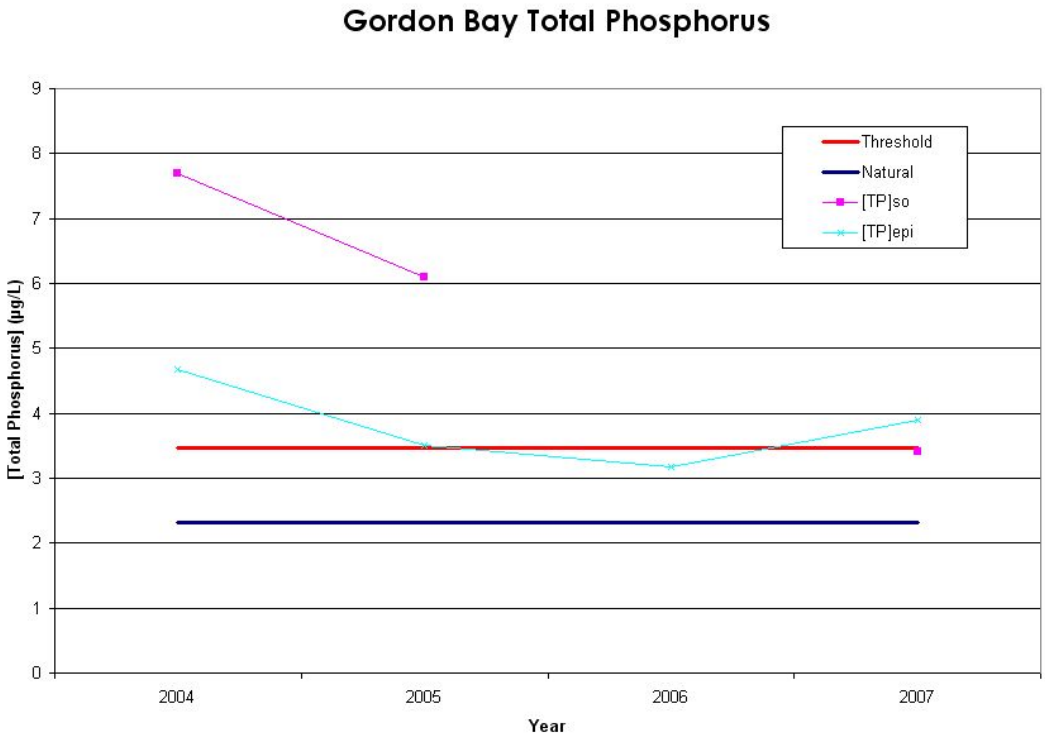

Figure 16 - Gordon Bay Total Phosphorus

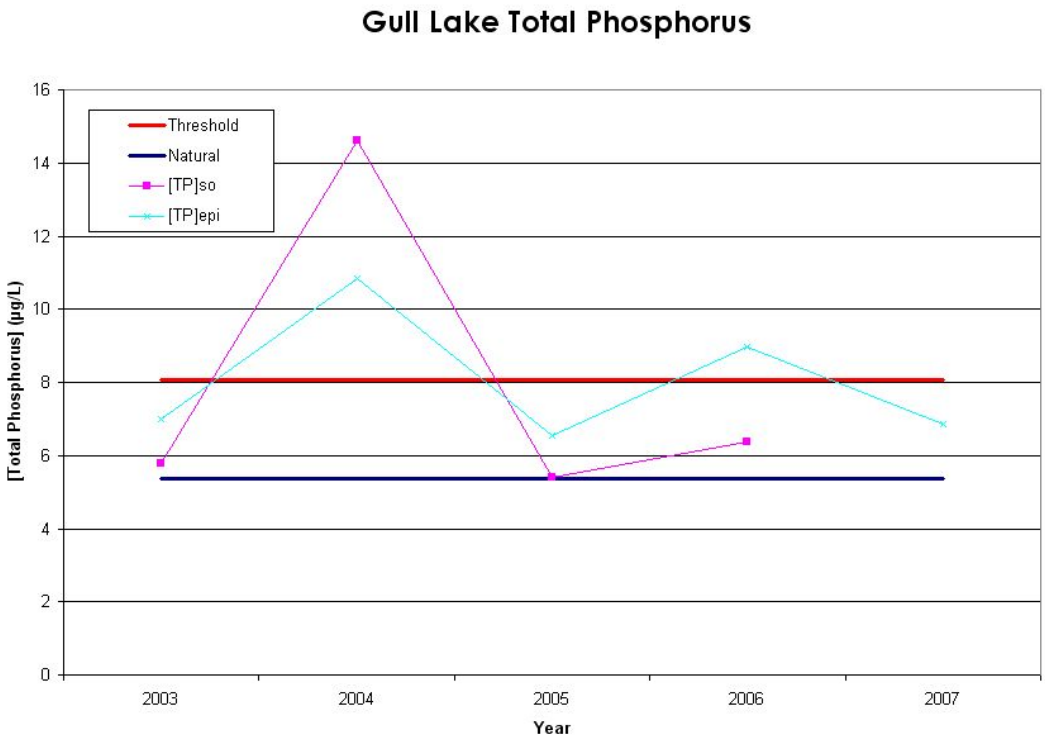

Figure 17 - Gull Lake Total Phosphorus

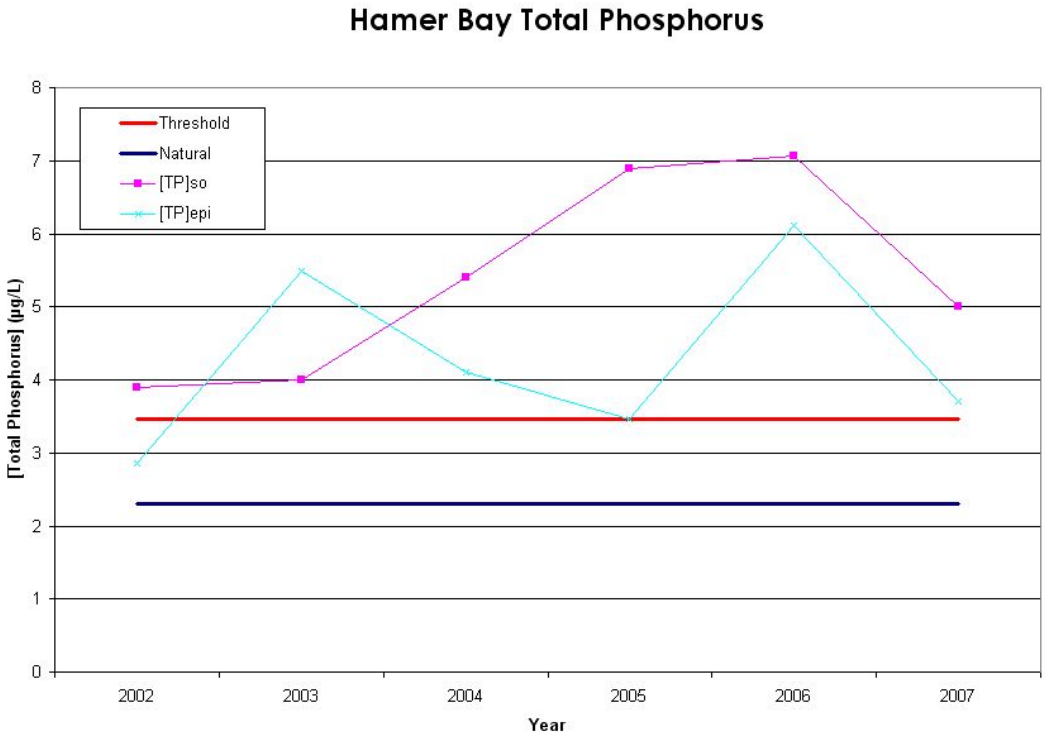

Figure 18 - Hamer Bay Total Phosphorus

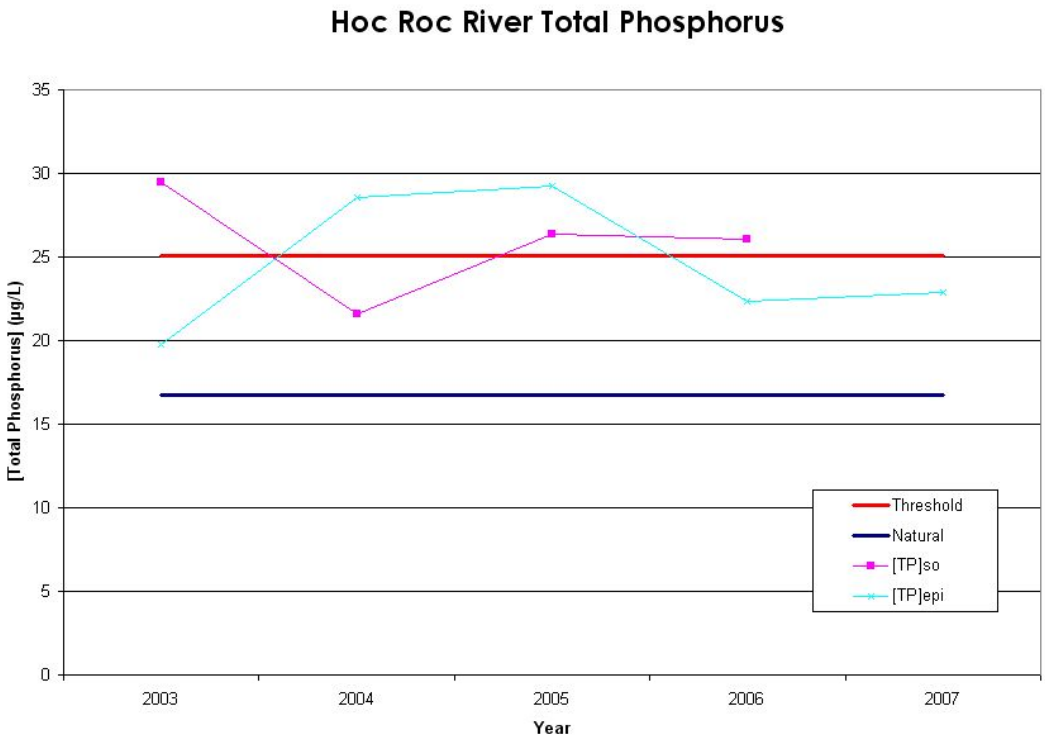

Figure 19 - Hoc Roc River Total Phosphorus

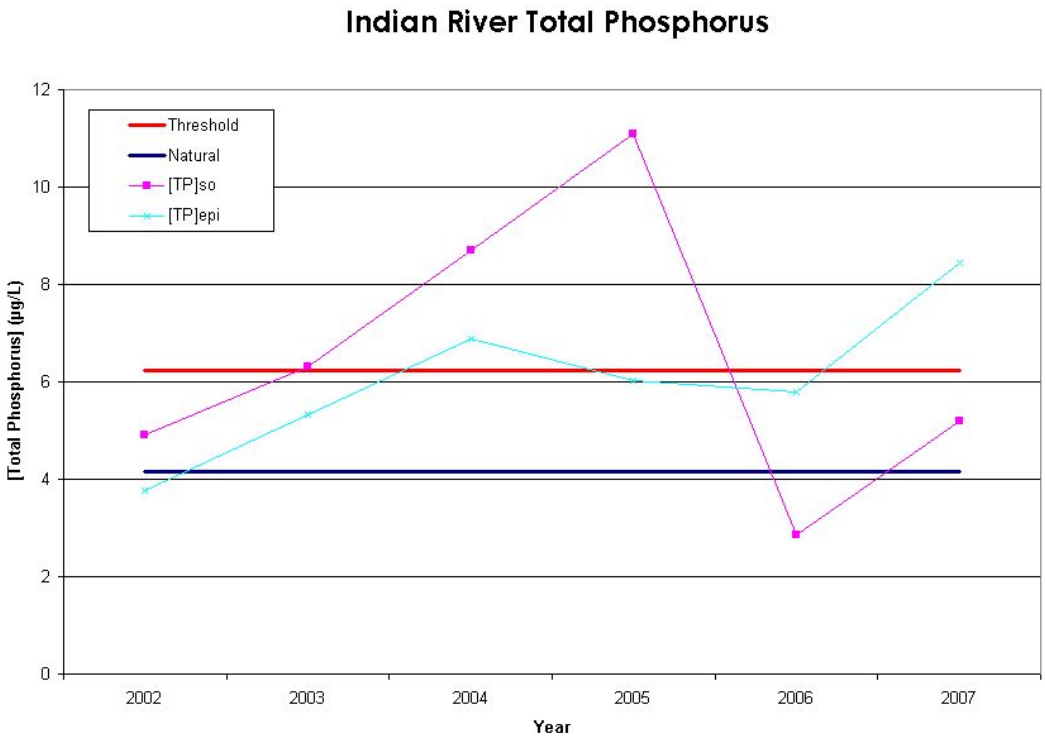

Figure 20 - Indian River Total Phosphorus

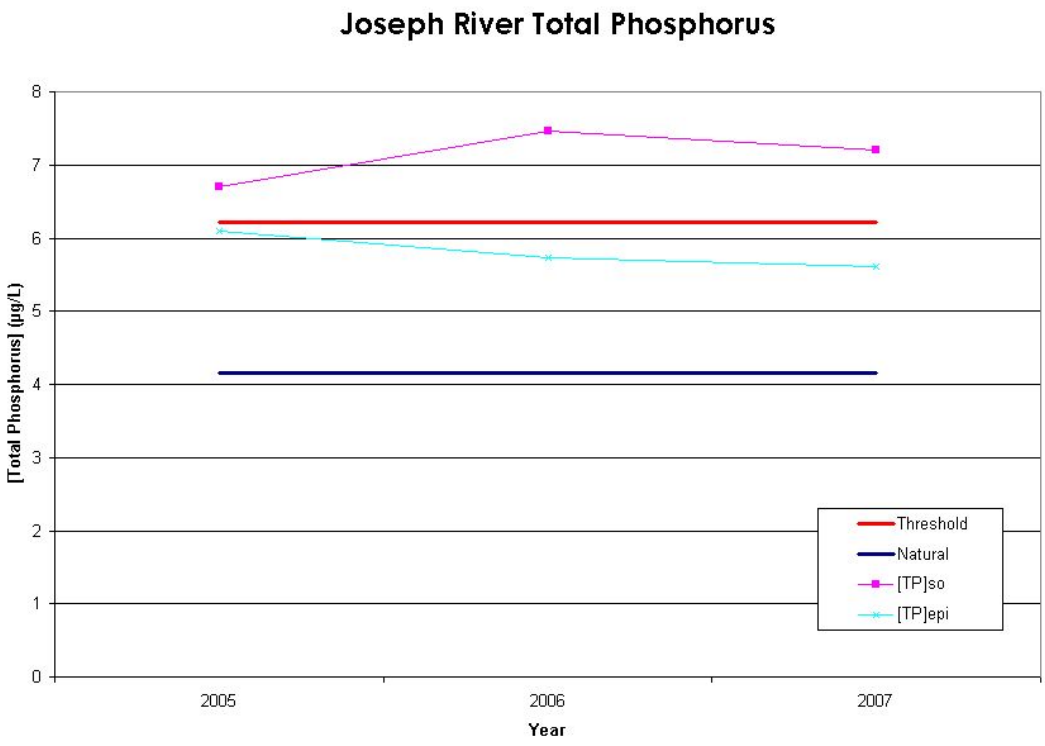

Figure 21 - Joseph River Total Phosphorus

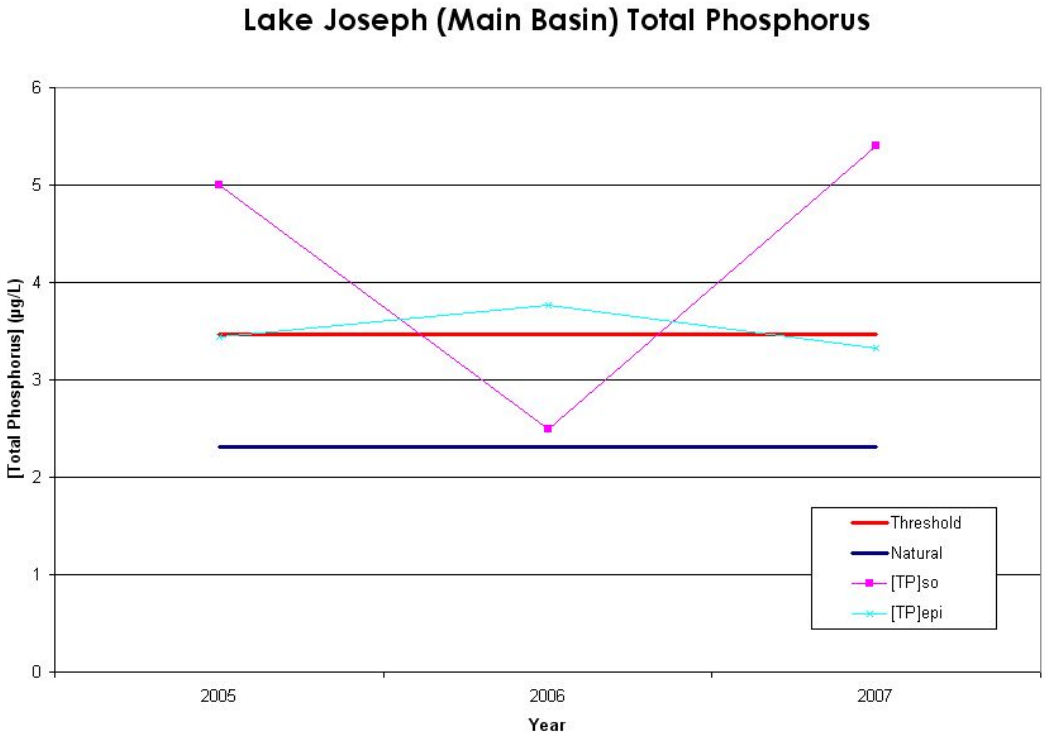

Figure 22 - Lake Joseph (Main Basin) Total Phosphorus

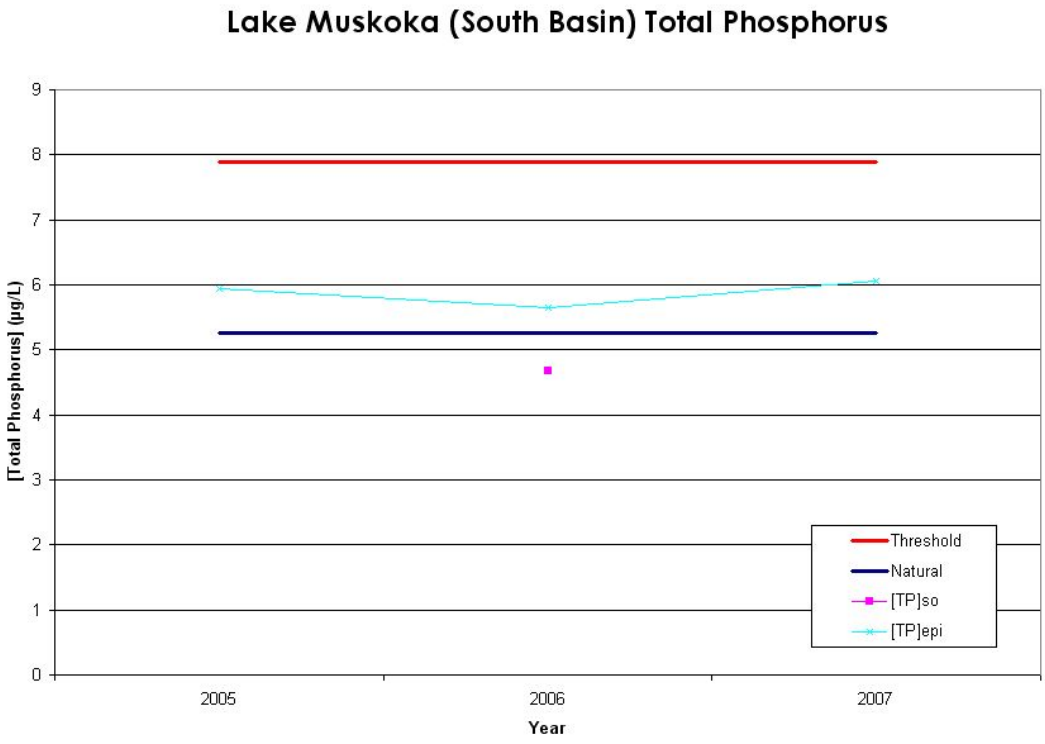

Figure 23 - Lake Muskoka (South Basin) Total Phosphorus

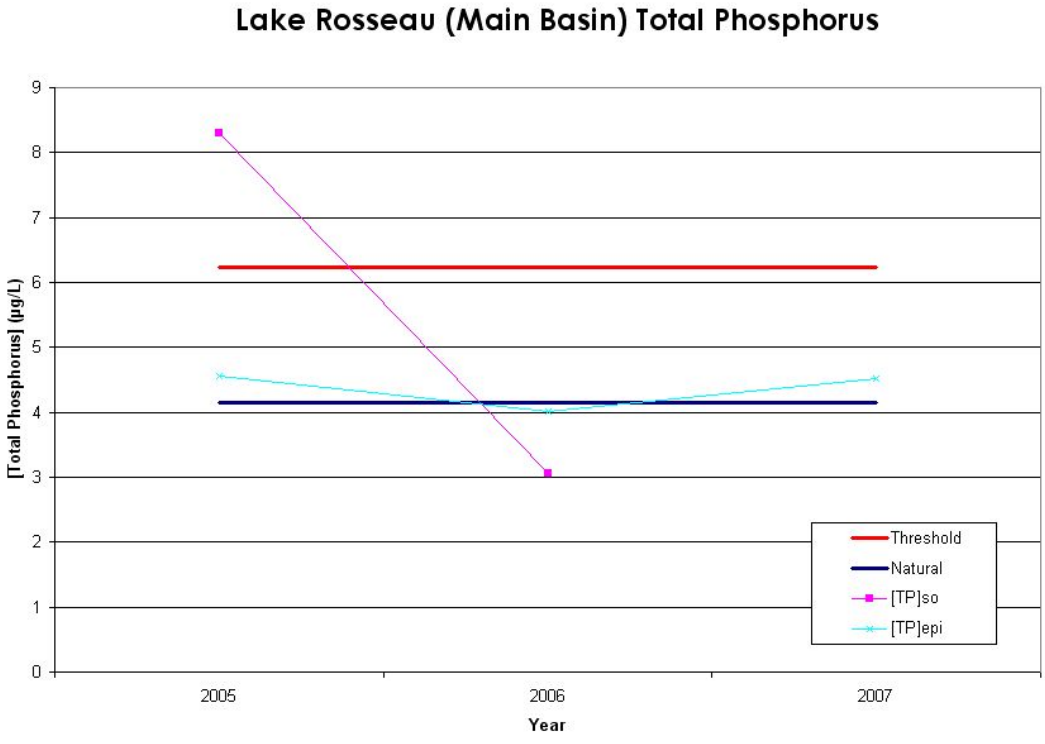

Figure 24 - Lake Rosseau (Main Basin) Total Phosphorus

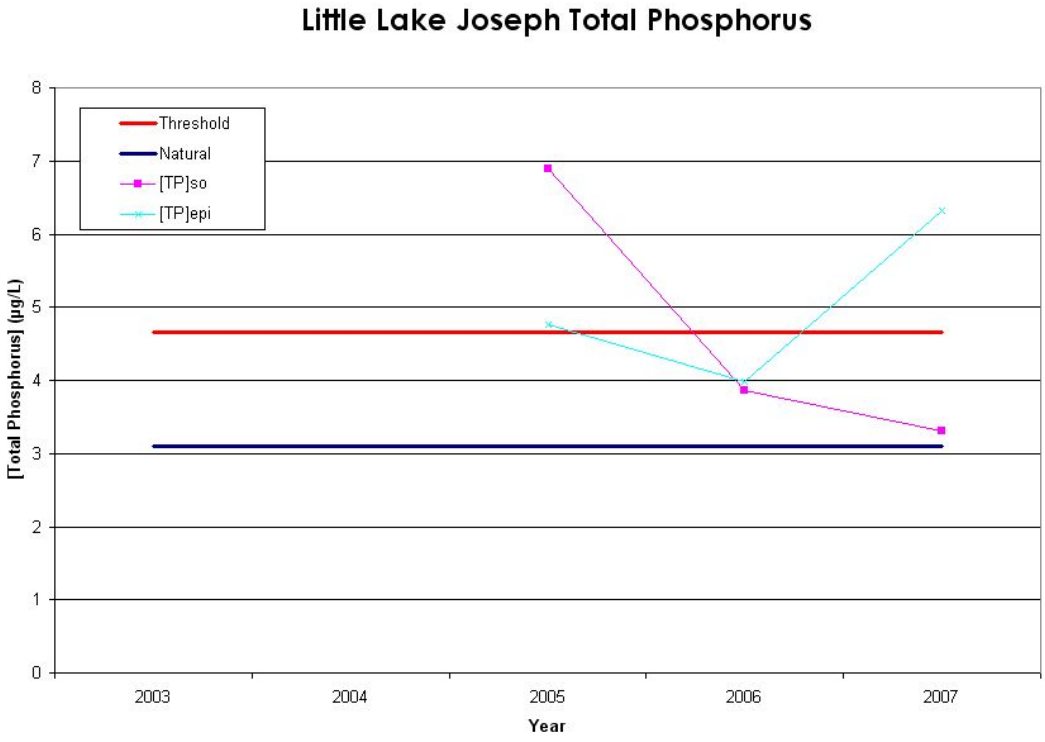

Figure 25 - Little Lake Joseph Total Phosphorus

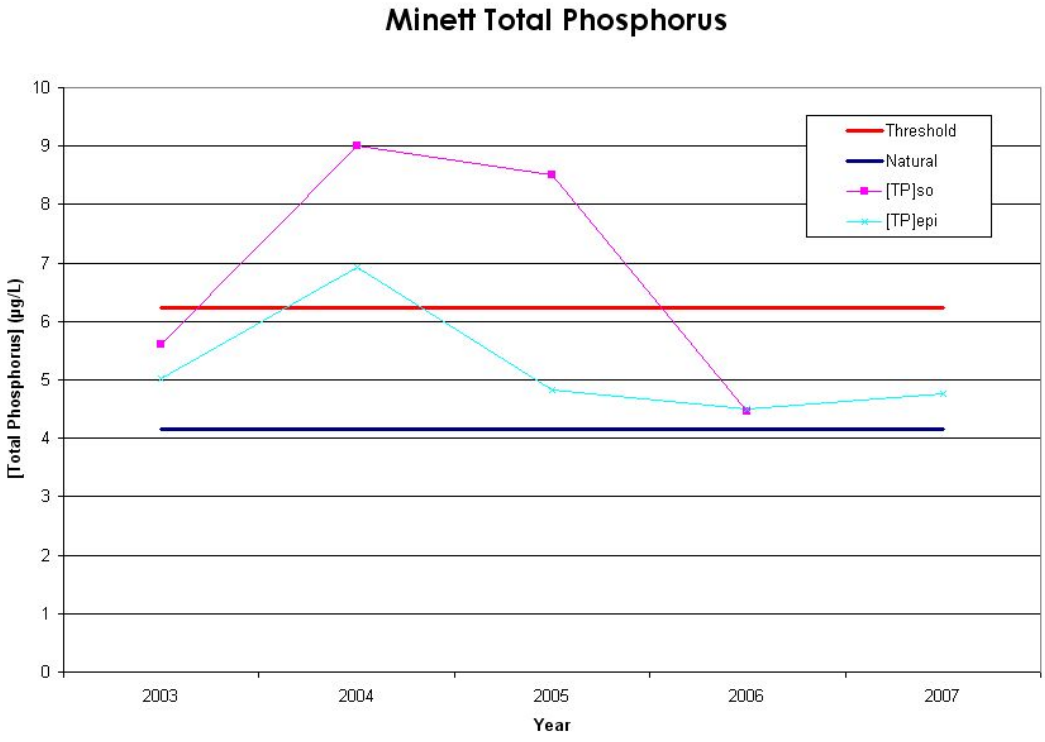

Figure 26 - Minett Total Phosphorus

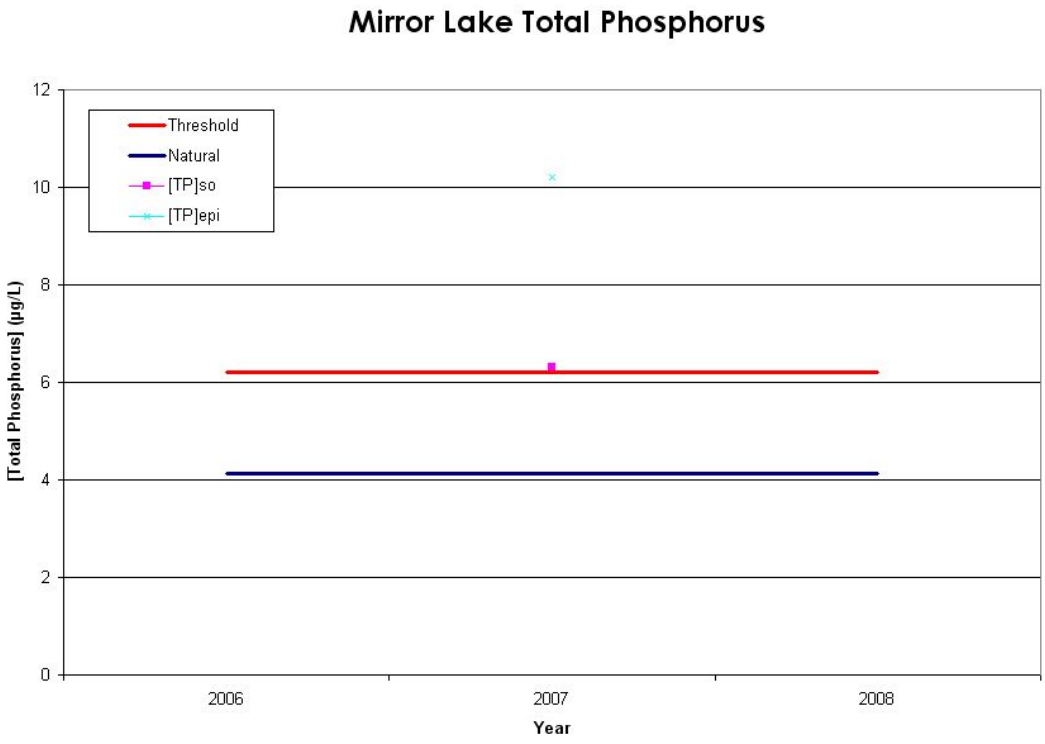

Figure 27 - Mirror Lake Total Phosphorus

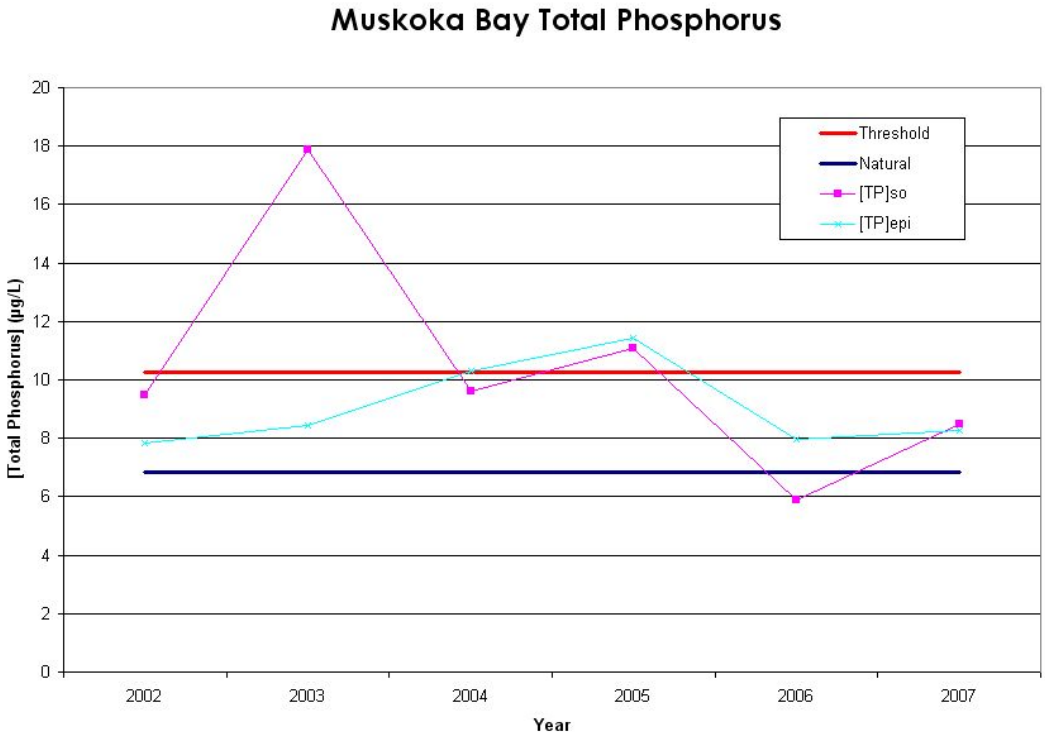

Figure 28 - Muskoka Bay Total Phosphorus

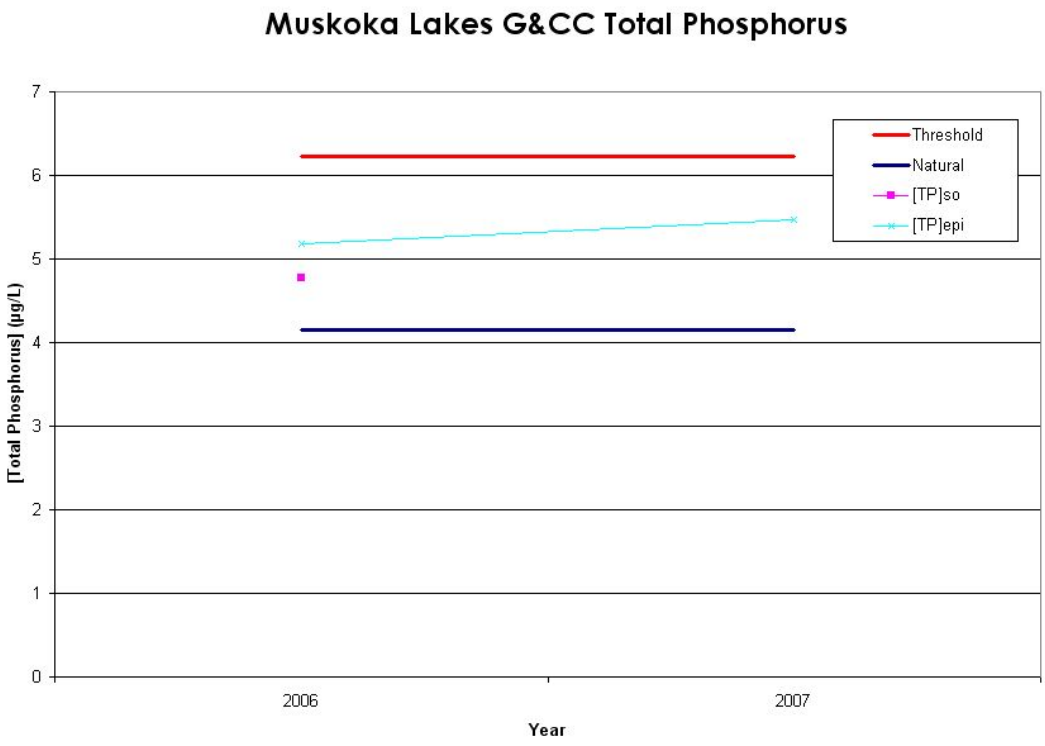

Figure 29 - Muskoka Lakes G & CC Total Phosphorus

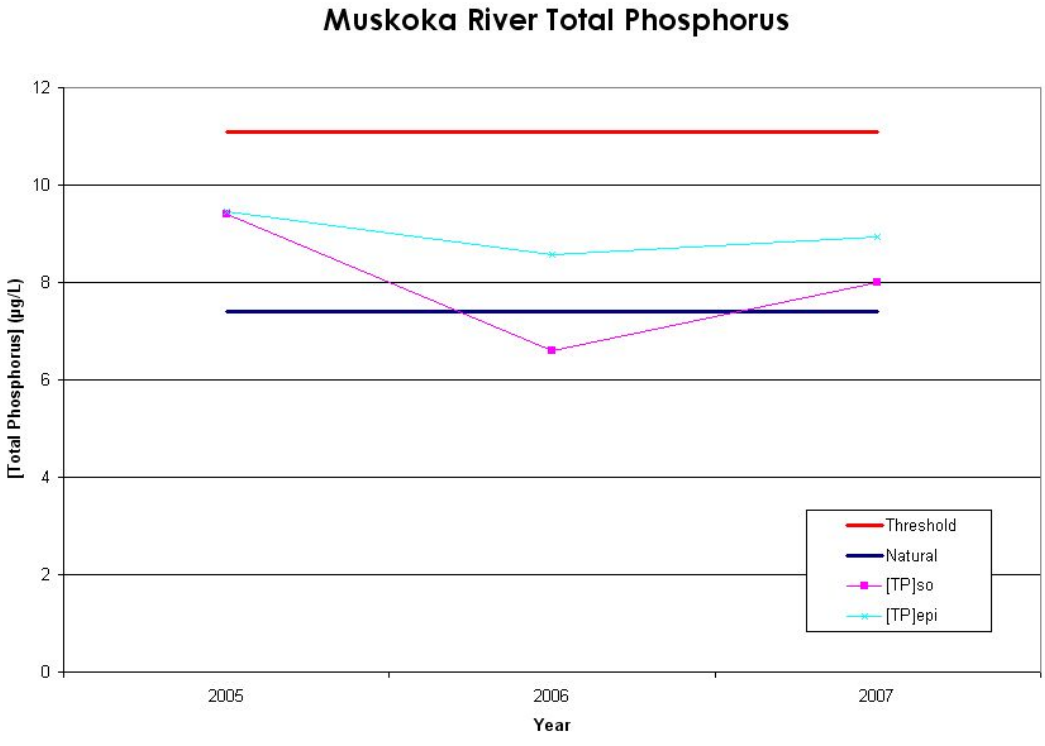

Figure 30 - Muskoka River Total Phosphorus

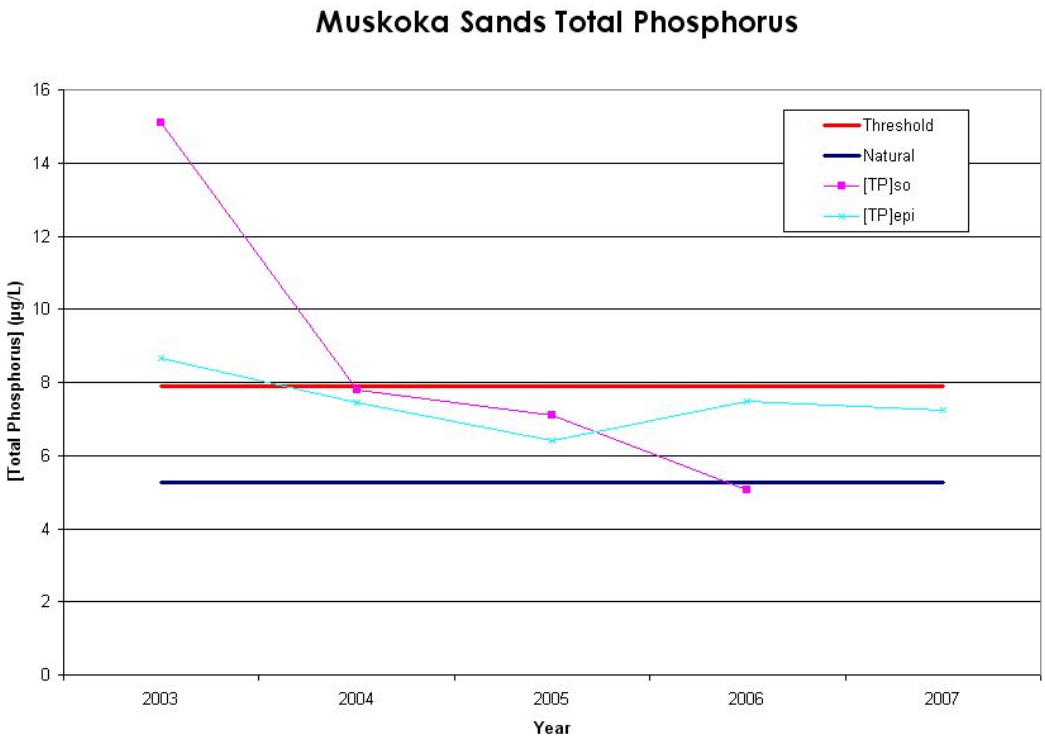

Figure 31 - Muskoka Sands Total Phosphorus

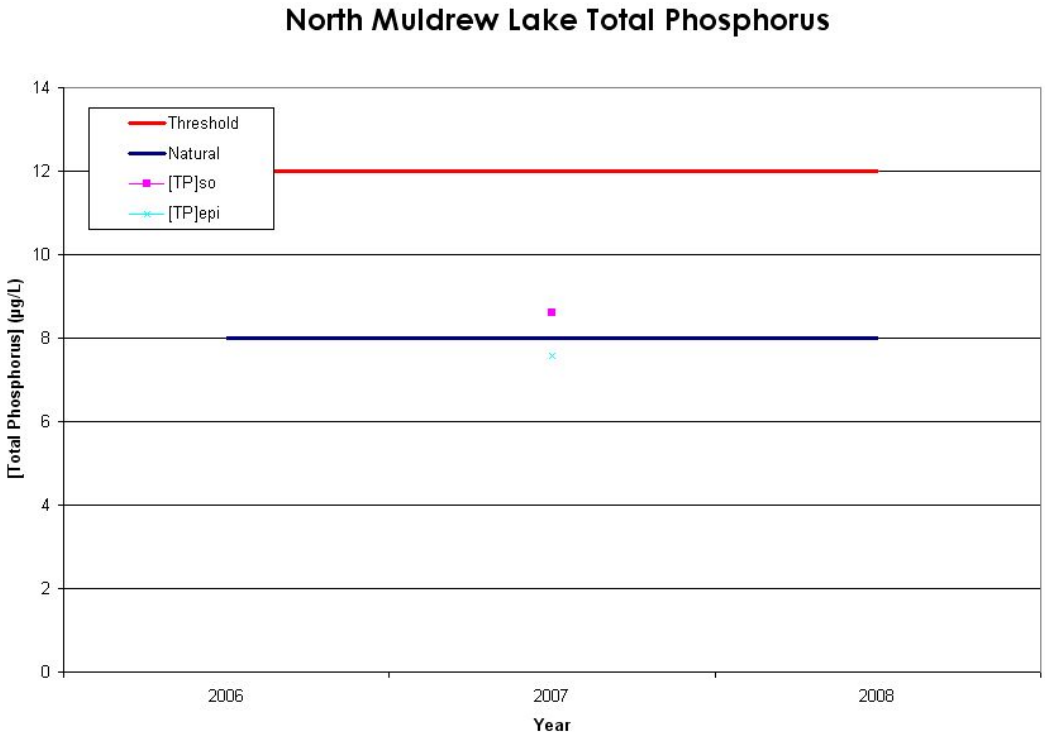

Figure 32 - North Muldrew Lake Total Phosphorus

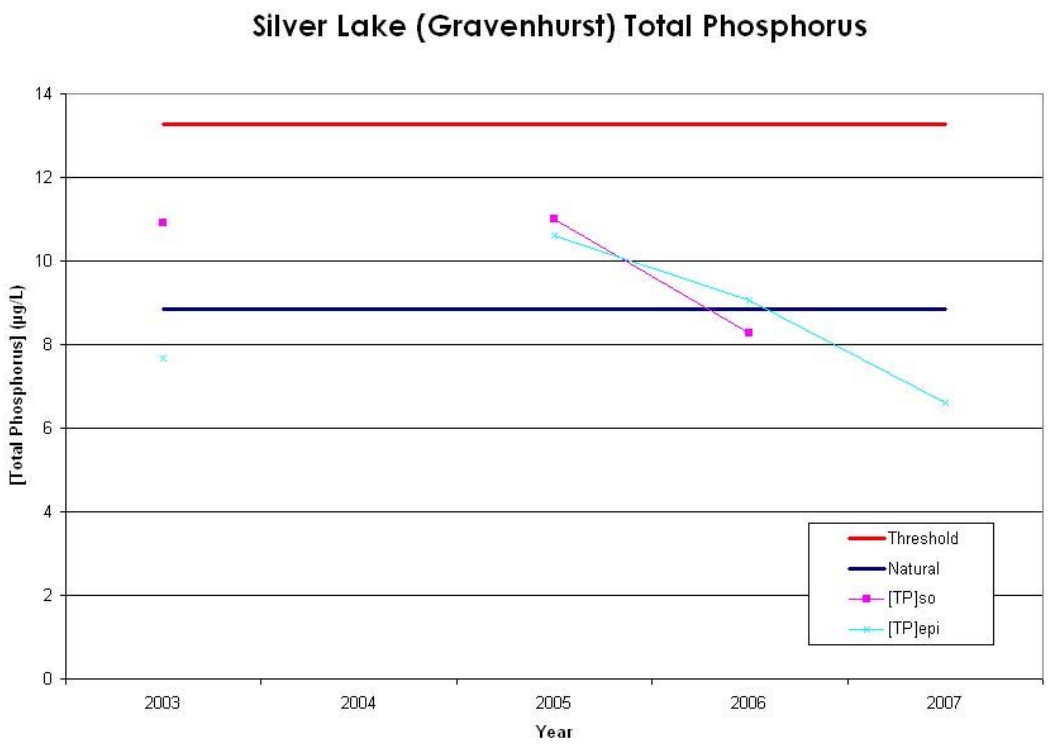

Figure 33 - Silver Lake (Gravenhurst) Total Phosphorus

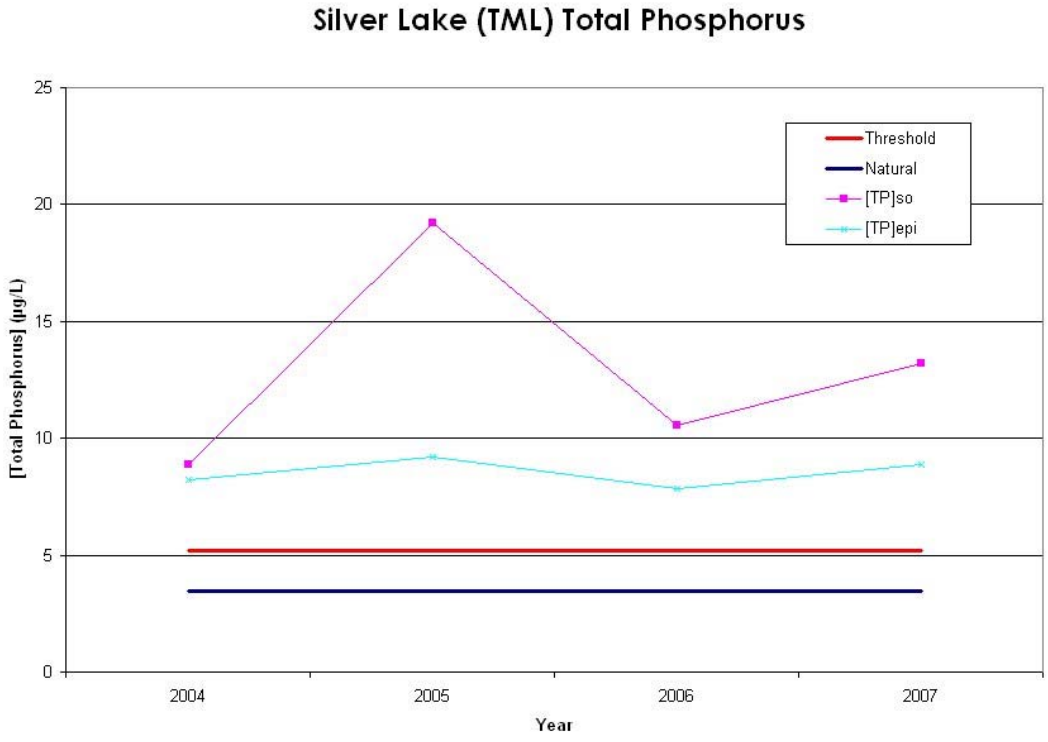

Figure 34 - Silver Lake (Muskoka Lakes) Total Phosphorus

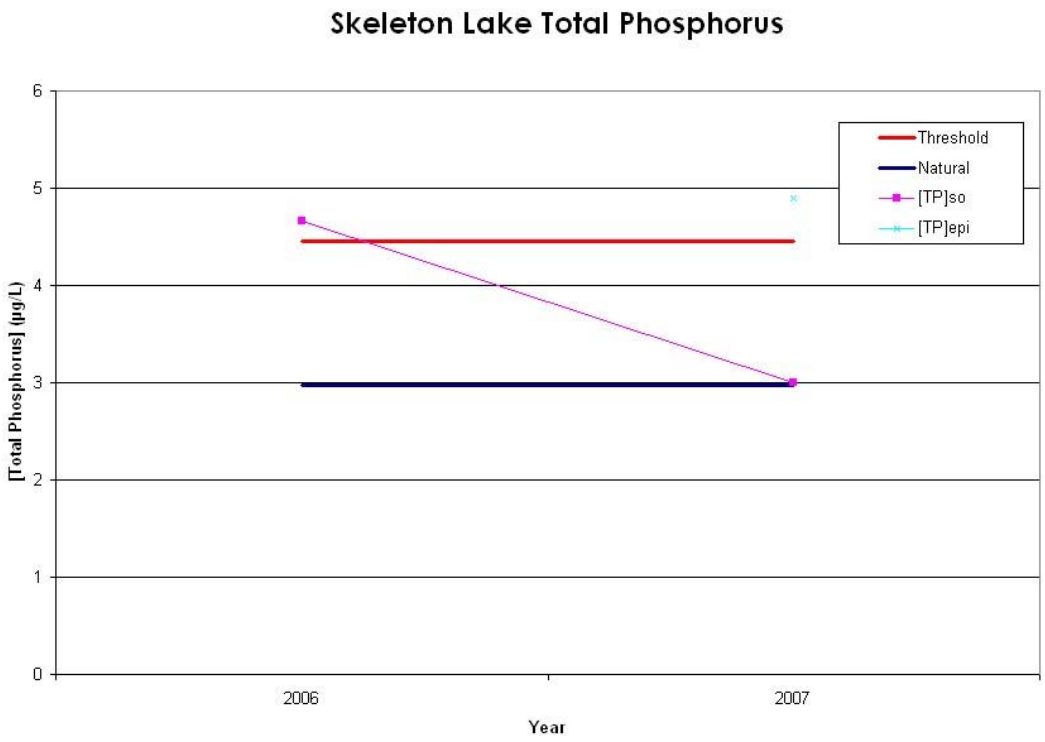

Figure 35 - Skeleton Lake Total Phosphorus

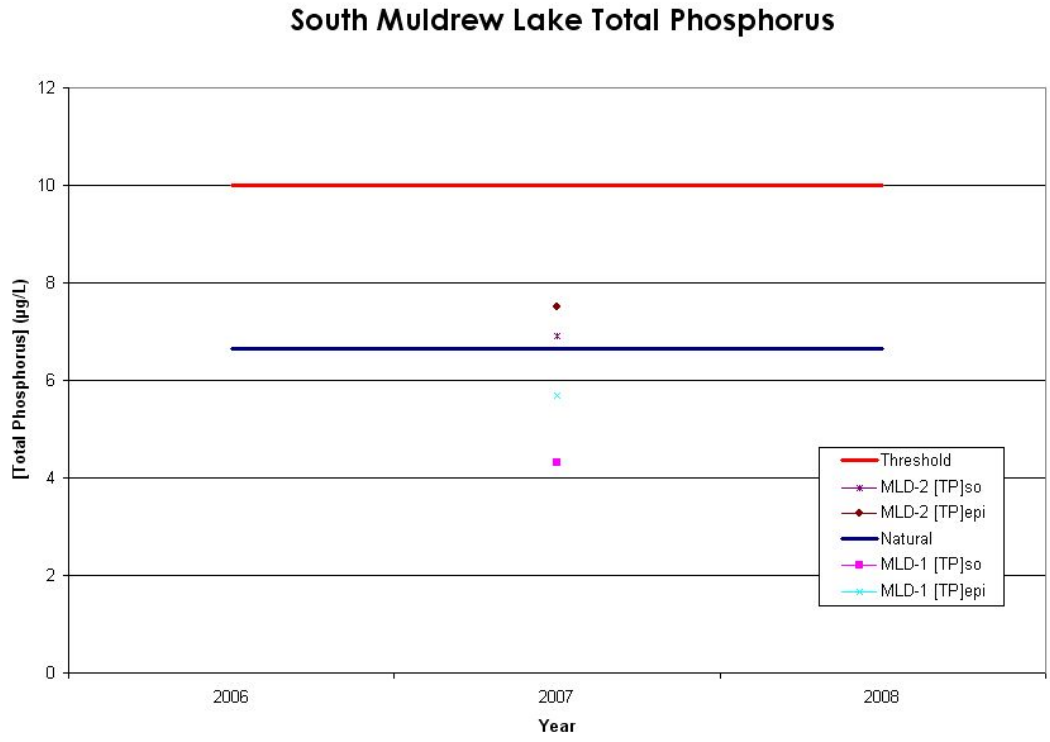

Figure 36 - South Muldrew Lake Total Phosphorus

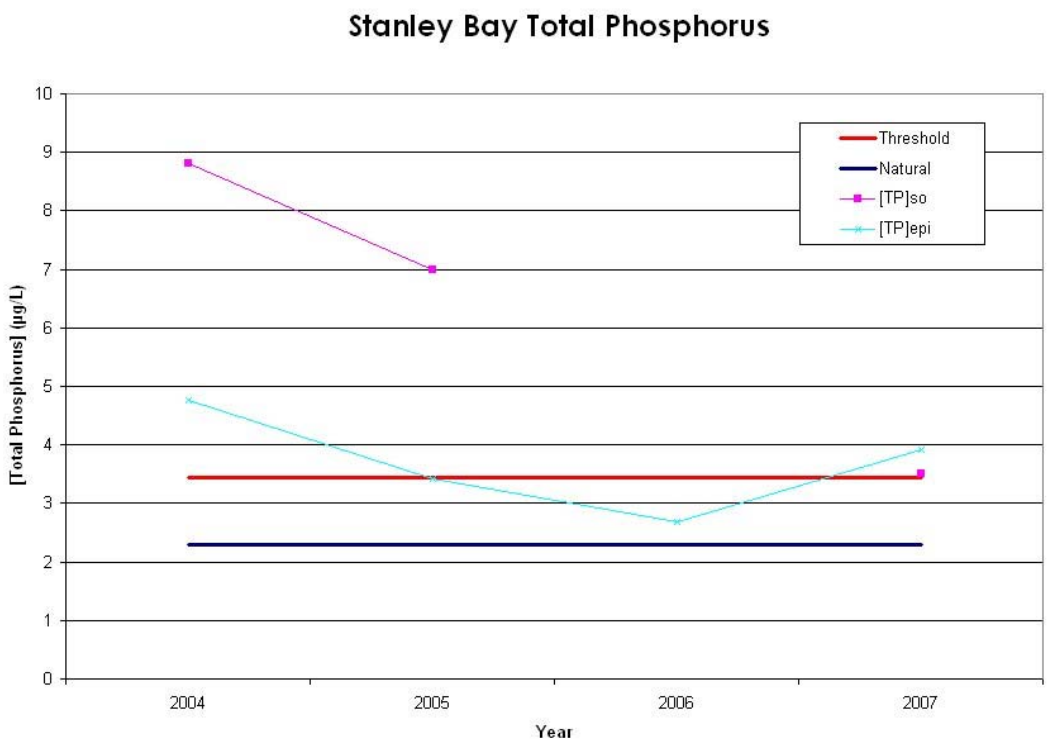

Figure 37 - Stanley Bay Total Phosphorus

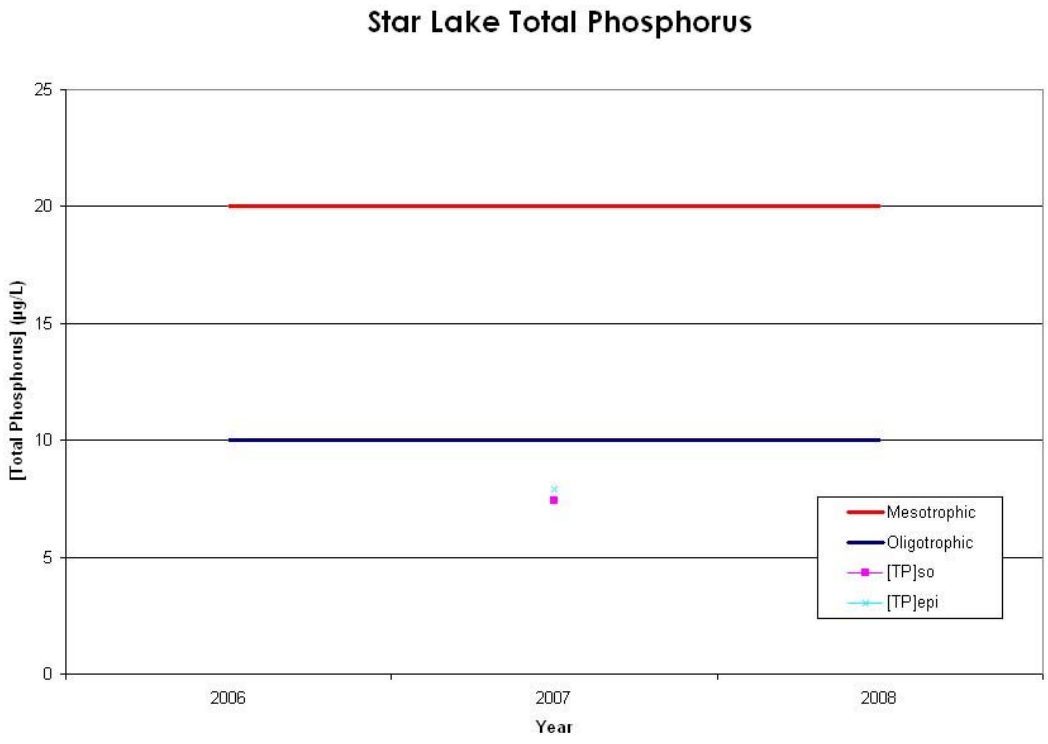

Figure 38 - Star Lake Total Phosphorus

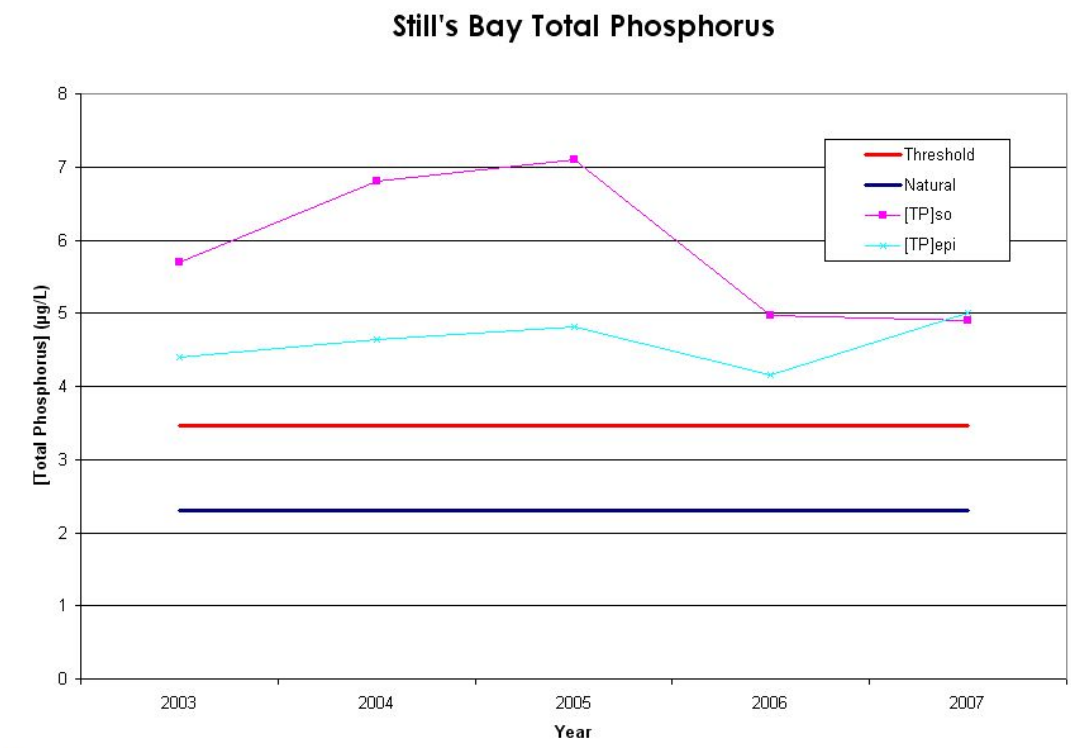

Figure 39 - Still's Bay Total Phosphorus

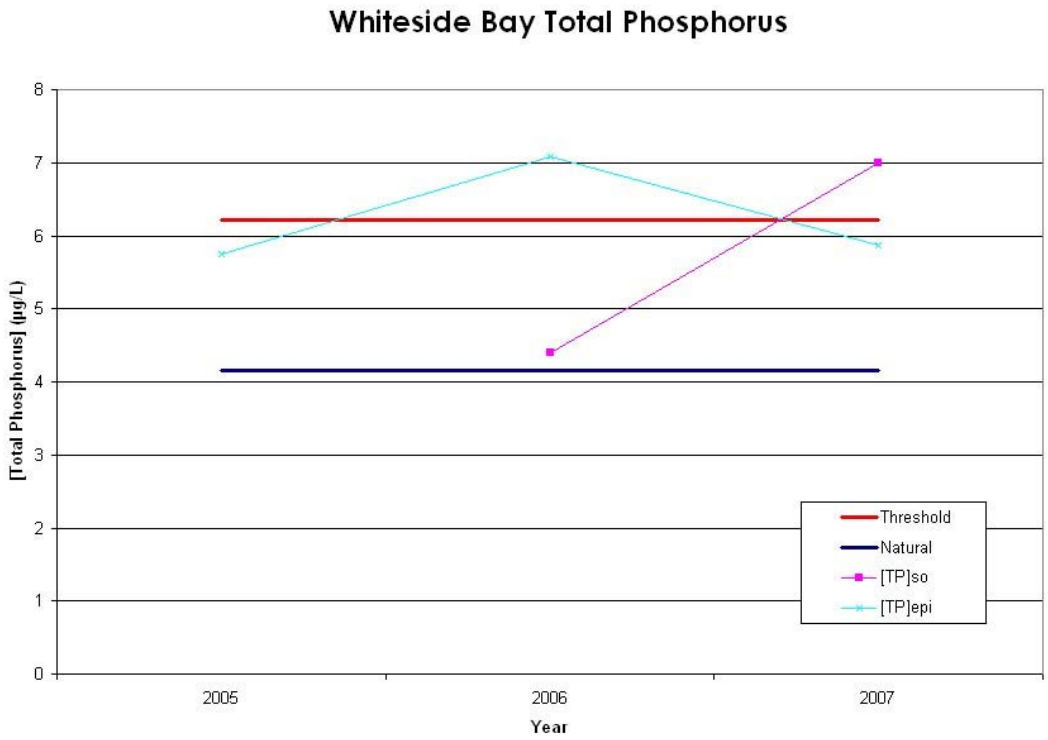

Figure 40 - Whiteside Bay Total Phosphorus

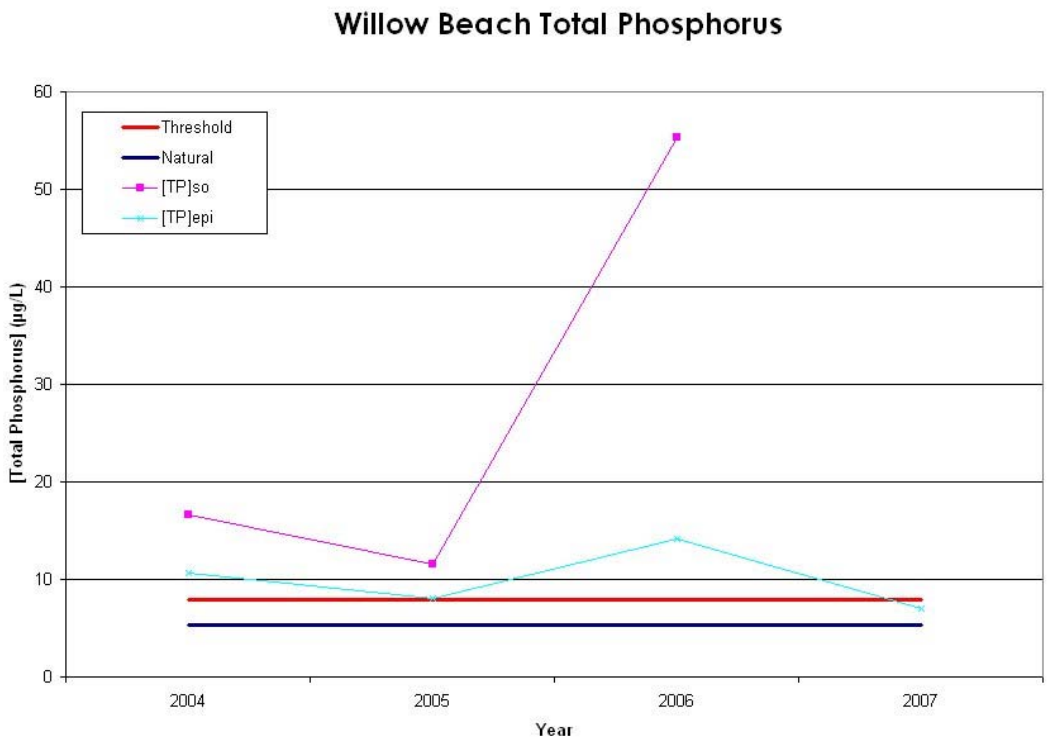

Figure 41 - Willow Beach Total Phosphorus

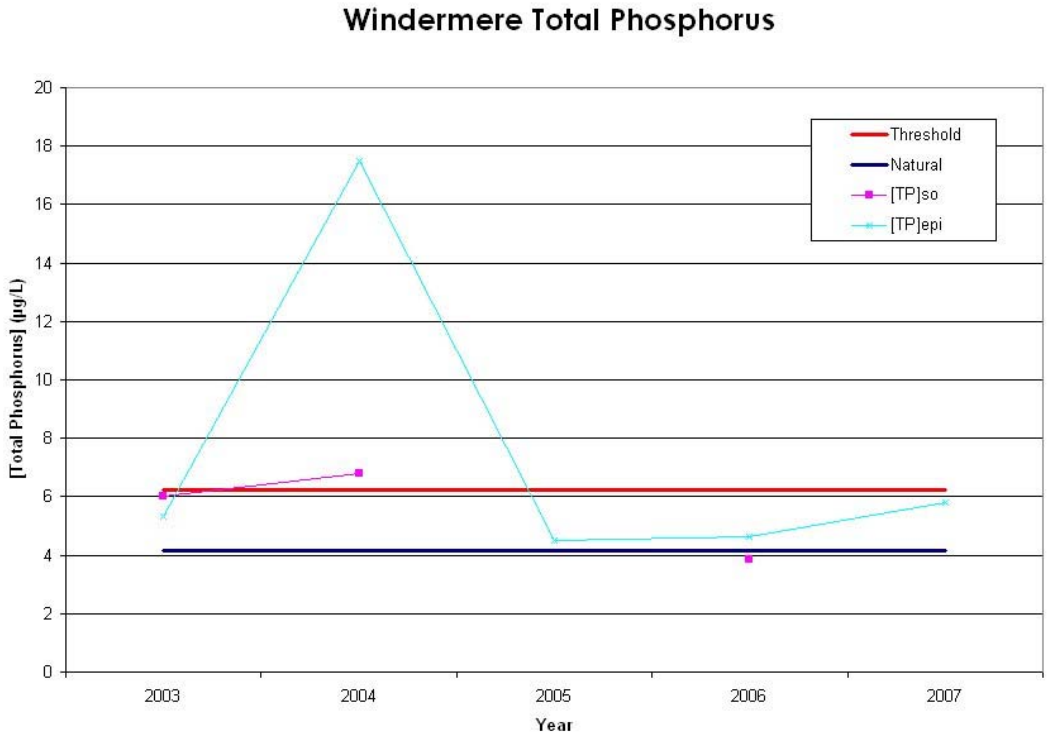

Figure 42 - Windermere Total Phosphorus